

# **Document made available under the Patent Cooperation Treaty (PCT)**

International application number: PCT/GB05/001350

International filing date: 13 April 2005 (13.04.2005)

Document type: Certified copy of priority document

Document details: Country/Office: US  
Number: 60/561,600  
Filing date: 13 April 2004 (13.04.2004)

Date of receipt at the International Bureau: 07 June 2005 (07.06.2005)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)



World Intellectual Property Organization (WIPO) - Geneva, Switzerland  
Organisation Mondiale de la Propriété Intellectuelle (OMPI) - Genève, Suisse

PA 1319524

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

May 13, 2005

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM  
THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK  
OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT  
APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A  
FILING DATE UNDER 35 USC 111.

APPLICATION NUMBER: 60/561,600

FILING DATE: April 13, 2004

GB/05/1350

By Authority of the  
COMMISSIONER OF PATENTS AND TRADEMARKS



*M. Tarver*

M. TARVER  
Certifying Officer

Please type a plus sign (+) inside this box → +

PTO/SB/16 (5-03)

Approved for use through 4/30/2003. OMB 0651-0032  
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**PROVISIONAL APPLICATION FOR PATENT COVER SHEET**

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

USPTO  
60/56160  
22154  
041304

| INVENTOR(S)  |                        |   |
|--|------------------------|---|
| Given Name (first and middle if any)   | Family Name or Surname | Residence<br>(City and either State or Foreign Country)                 |
| Adrian Liam<br>Maria   | Gill<br>Carr           | Cambridge, United Kingdom<br>Cambridge, United Kingdom                  |
| <input type="checkbox"/> Additional inventors are being named on the _____ separately numbered sheets attached hereto                            |                        |   |
| TITLE OF THE INVENTION (280 characters max)<br><b>PHARMACEUTICAL COMPOUNDS</b>   |                        |   |
| Direct all correspondence to: CORRESPONDENCE ADDRESS   |                        |   |
| <input checked="" type="checkbox"/> Customer Number  | 23405                  | →<br><input type="checkbox"/> Place Customer Number Bar Code Label here |
| OR<br><i>Type Customer Number here</i>   |                        |   |
| <input type="checkbox"/> Firm or Individual Name   |                        |   |
| Address  |                        |   |
| Address  |                        |   |
| City   | State                  | ZIP   |
| Country  | Telephone              | Fax   |
| ENCLOSED APPLICATION PARTS (check all that apply)  |                        |   |
| <input checked="" type="checkbox"/> Specification  | Number of Pages<br>59  | <input type="checkbox"/> CD(s), Number                                  |
| <input type="checkbox"/> Drawing(s)  | Number of Sheets       | <input type="checkbox"/> Other (specify)                                |
| <input checked="" type="checkbox"/> Application Data Sheet. See 37 CFR 1.76  |                        |   |
| METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT (check one)   |                        |   |
| <input checked="" type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27.   | FILING FEE AMOUNT (\$) |   |
| <input checked="" type="checkbox"/> A check or money order is enclosed to cover the filing fees  |                        |   |
| <input checked="" type="checkbox"/> The Director is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: | 08-1935                | \$80.00   |
| <input type="checkbox"/> Payment by credit card. Form PTO-2038 is attached.  |                        |   |
| The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.          |                        |   |
| <input checked="" type="checkbox"/> No.  |                        |   |
| <input type="checkbox"/> Yes, the name of the U.S. Government agency and the Government contract number are: _____                               |                        |   |

Respectfully submitted,

SIGNATURE

TYPED or PRINTED NAME Philip E. Hansen

518-452-5600

TELEPHONE \_\_\_\_\_

Date

04/13/04

REGISTRATION NO.

32,700

(if appropriate)

Docket Number:

2245.009P

**USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT**

This collection of information is required by 37 CFR 1.51. The information is used by the public to file (and by the PTO to process) a provisional application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the complete provisional application to the PTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop Provisional Application, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

P18SMALL/REV05

## **CERTIFICATE OF MAILING BY "EXPRESS MAIL"**

Applicant: Adrian Liam Gill and Maria Carr

Title: PHARMACEUTICAL COMPOUNDS

Attorney Docket No.: 2245.009P

"EXPRESS MAIL" Mailing Label No.: EV 988074889 US

Date of Deposit: April 13, 2004

Enclosed are:

- \* Express Mail Certificate - Label No.: EV 988074889 US
- \* One (1) Acknowledgment Postcard
- \* Check for \$80.00 (Provisional Patent Application filing fee) (Small Entity)
- \* Provisional Application for Patent Cover Sheet (1 page)
- \* Provisional Patent Application (59 pages)
- \* Application Data Sheet (2 page)

### 37 CFR 1.10 Certification

I hereby certify that this paper and the indicated enclosures are being deposited with the U.S. Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and addressed to:

Mail Stop Provisional Application  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Kathryn Frederick  
(Typed or printed name of person mailing paper or fee)

  
(Signature of person mailing paper or fee)

## PHARMACEUTICAL COMPOUNDS

This invention relates to compounds that inhibit or modulate the activity of p38 MAP kinase and to the use of the compounds in the treatment or prophylaxis of disease states or conditions mediated by p38 MAP kinase. Also provided are  
5 pharmaceutical compositions containing the compounds and novel chemical intermediates.

### Background of the Invention

Protein kinases constitute a large family of structurally related enzymes that are responsible for the control of a wide variety of signal transduction processes within  
10 the cell (Hardie, G. and Hanks, S. (1995) *The Protein Kinase Facts Book. I and II*, Academic Press, San Diego, CA). The kinases may be categorized into families by the substrates they phosphorylate (e.g., protein-tyrosine, protein-serine/threonine, lipids, etc.). Sequence motifs have been identified that generally correspond to each of these kinase families (e.g., Hanks, S.K., Hunter, T., *FASEB J.*, 9:576-596 (1995);  
15 Knighton, *et al.*, *Science*, 253:407-414 (1991); Hiles, *et al.*, *Cell*, 70:419-429 (1992); Kunz, *et al.*, *Cell*, 73:585-596 (1993); Garcia-Bustos, *et al.*, *EMBO J.*, 13:2352-2361 (1994)).

Protein kinases may be characterized by their regulation mechanisms. These mechanisms include, for example, autophosphorylation, transphosphorylation by  
20 other kinases, protein-protein interactions, protein-lipid interactions, and protein-polynucleotide interactions. An individual protein kinase may be regulated by more than one mechanism.

Kinases regulate many different cell processes including, but not limited to, proliferation, differentiation, apoptosis, motility, transcription, translation and other  
25 signaling processes, by adding phosphate groups to target proteins. These phosphorylation events act as molecular on/off switches that can modulate or regulate the target protein biological function. Phosphorylation of target proteins occurs in response to a variety of extracellular signals (hormones, neurotransmitters, growth and differentiation factors, etc.), cell cycle events,

environmental or nutritional stresses, etc. The appropriate protein kinase functions in signaling pathways to activate or inactivate (either directly or indirectly), for example, a metabolic enzyme, regulatory protein, receptor, cytoskeletal protein, ion channel or pump, or transcription factor. Disruption of intracellular signal

5 transduction due to defective control of protein phosphorylation has been implicated in a number of diseases, including, for example, inflammation, cancer, allergy/asthma, disease and conditions of the immune system, disease and conditions of the central nervous system, and angiogenesis.

The mitogen-activated protein (MAP) kinase family consists of a series of  
10 structurally related proline-directed serine/threonine kinases that are activated either by growth factors (such as EGF) and phorbol esters (ERK), or by IL-1, TNF or stress (p38, JNK). These kinases mediate the effects of numerous extracellular stimuli on a wide array of biological processes, such as cell proliferation, differentiation and death. Three groups of mammalian MAP kinases have been  
15 studied in detail: the extracellular signal-regulated kinases (ERK), the c-Jun NH<sub>2</sub>-terminal kinases (JNK) and the p38 MAP kinases.

There are five known human isoforms of p38 MAP kinase, p38 $\alpha$ , p38 $\beta$ , p38 $\beta$ 2, p38 $\gamma$  and p38 $\delta$ . The p38 kinases, which are also known as cytokine suppressive anti-inflammatory drug binding proteins (CSBP), stress activated protein kinases  
20 (SAPK) and RK, are responsible for phosphorylating (Stein *et al.*, *Ann. Rep. Med. Chem.*, 31, 289-298 (1996)) and activating transcription factors (such as ATF-2, MAX, CHOP and C/ERPb) as well as other kinases (such as MAPKAP-K2/3 or MK2/3), and are themselves activated by physical and chemical stress (e.g. UV, osmotic stress), pro-inflammatory cytokines and bacterial lipopolysaccharide (LPS)  
25 (Herlaar, E & Brown, Z., *Molecular Medicine Today*, 5: 439-447 (1999)). The products of p38 phosphorylation have been shown to mediate the production of inflammatory cytokines, including TNF and IL-1, and cyclooxygenase-2 (COX-2). Each of these cytokines has been implicated in numerous disease states and conditions. IL-1 and TNF are also known to stimulate the production of other  
30 proinflammatory cytokines such as IL-6 and IL-8.

Interleukin-1 (IL-1) and Tumor Necrosis Factor (TNF) are biological substances produced by a variety of cells, such as monocytes or macrophages. IL-1 has been demonstrated to mediate a variety of biological activities thought to be important in immunoregulation and other physiological conditions such as inflammation (e.g.

5     Dinarello, *et al.*, *Rev. Infect. Disease*, 6: 51 (1984)). The myriad of known biological activities of IL-1 include the activation of T helper cells, induction of fever, stimulation of prostaglandin or collagenase production, neutrophil chemotaxis, induction of acute phase proteins and the suppression of plasma iron levels.

10    There are many disease states in which excessive or unregulated IL-1 production is implicated in exacerbating and/or causing the disease. These include rheumatoid arthritis (Arend *et al.*, *Arthritis & Rheumatism* 38(2): 151-160, osteoarthritis, endotoxemia and/or toxic shock syndrome, other acute or chronic inflammatory disease states such as the inflammatory reaction induced by endotoxin or

15    inflammatory bowel disease; tuberculosis, atherosclerosis, Hodgkin's disease (Benharroch *et al.*, *Euro. Cytokine Network* 7(1): 51-57), muscle degeneration, cachexia, psoriatic arthritis, Reiter's syndrome, gout, traumatic arthritis, rubella arthritis, acute synovitis and Alzheimer's disease. Evidence also links IL-1 activity to diabetes and pancreatic B cells (Dinarello, *J. Clinical Immunology*, 5: 287-297

20    (1985)). Because inhibition of p38 leads to inhibition of IL-1 production, it is envisaged that p38 inhibitors will be useful in the treatment of the above listed diseases.

Excessive or unregulated TNF production has been implicated in mediating or exacerbating a number of diseases including rheumatoid arthritis (Maini *et al.*,

25    *APMIS*, 105(4): 257-263), rheumatoid spondylitis, osteoarthritis, gouty arthritis and other arthritic conditions; sepsis, septic shock, endotoxic shock, gram negative sepsis, toxic shock syndrome, adult respiratory distress syndrome, cerebral malaria, chronic pulmonary inflammatory disease, silicosis, pulmonary sarcoidosis, bone resorption diseases, reperfusion injury, graft vs. host reaction, allograft rejections,

30    fever and myalgias due to infection, such as influenza, herpes simplex virus type-1 (HSV-1), HSV-2, cytomegalovirus (CMV), varicella-zoster virus (VZV), Epstein-

Barr virus (EBV), human herpes virus-6 (HHV-6), HHV-7, HHV-8, pseudorabies, rhinotracheitis and cachexia secondary to infection or malignancy, cachexia secondary to acquired immune deficiency syndrome (AIDS), AIDS, ARC (AIDS related complex), keloid formation, scar tissue formation, Crohn's disease, 5 ulcerative colitis, or pyresis. Because inhibition of p38 leads to inhibition of TNF production, it is envisaged that p38 inhibitors will be useful in the treatment of the above listed diseases.

Interleukin-8 (IL-8) is a chemotactic factor produced by several cell types including mononuclear cells, fibroblasts, endothelial cells, and keratinocytes. Its production 10 from endothelial cells is induced by IL-1, TNF, or lipopolysaccharide (LPS). IL-8 stimulates a number of functions *in vitro*. It has been shown to have chemoattractant properties for neutrophils, T-lymphocytes, and basophils. In addition it induces histamine release from basophils from both normal and atopic individuals as well as lysozomal enzyme release and respiratory burst from 15 neutrophils. IL-8 has also been shown to increase the surface expression of Mac-1 (CD 11 b/CD 18) on neutrophils without *de novo* protein synthesis; this may contribute to increased adhesion of the neutrophils to vascular endothelial cells. Many diseases are characterized by massive neutrophil infiltration. Conditions associated with an increased in IL-8 production (which is responsible for 20 chemotaxis of neutrophils into the inflammatory site) would benefit from treatment with compounds which are suppressive of IL-8 production. Recently Chronic Obstructive Pulmonary Disease (COPD) has been linked to raised levels of IL-8 and neutrophil infiltration of the lung (Barnes *et al.*, *Curr. Opin. Pharmacol.*, 1: 242-7 (2001)). Other conditions linked to IL-8 include acute respiratory distress 25 syndrome (ARDS), asthma, pulmonary fibrosis and bacterial pneumonia.

IL-1 and TNF affect a wide variety of cells and tissues and these cytokines as well as other leukocyte derived cytokines are important and critical inflammatory mediators of a wide variety of disease states and conditions. The inhibition of these cytokines is of benefit in controlling, reducing and alleviating many of these disease 30 states.

Inhibition of signal transduction via p38, which in addition to IL-1, TNF and IL-8 described above is also required for the synthesis and/or action of several additional pro-inflammatory proteins (i.e., IL-6, GM-CSF, COX-2, collagenase and stromelysin), is expected to be a highly effective mechanism for regulating the

5 excessive and destructive activation of the immune system. This expectation is supported by the potent and diverse anti-inflammatory activities described for p38 kinase inhibitors (Badger, *et al.*, *J. Pharm. Exp. Thera.*, 279: 1453-1461(1996); Griswold, *et al.*, *Pharmacol. Comm.*, 7: 323-229 (1996)).

WO 00/71535 (Scios Inc.) discloses indole-type compounds as inhibitors of p38  
10 kinase.

WO 93/1408 (Smith-Kline Beecham) discloses 1,3,4-triaryl imidazoles as inhibitors of p38 MAP kinase.

WO 99/15164 (Zeneca) discloses various bis-benzamidophenyl derivatives compounds which exhibit inhibition of p38 activity.

15 WO 99/32111 (Bayer) discloses a series of diarylurea compounds which act as p38 MAP kinase inhibitors.

WO 99/00357 (Vertex) discloses a further class of diarylurea compounds as p38 MAP kinase inhibitors.

EP 1253142 discloses various heteroaryl compounds as thrombopoietin receptor  
20 agonists.

WO 01/40223 discloses a class of pesticidal substituted aminoheterocycllamides.

An article by A. R. Redman *et al*, in *Bioorganic & Medicinal Chemistry Letters*, 11, 9-12, (2001) describes thienyl compounds, in particular thienyl ureas, having p38 kinase inhibitory activity. The compounds disclosed in Redman *et al* are  
25 characterised by the presence of an aryl ureido group at the 3-position of the thiophene ring.

WO 99/32111 and WO 99/32463 (both to Bayer Corporation) each disclose a class of diaryl/heteroaryl urea compounds as MAP kinase inhibitors. The compounds can contain a 5-substituted thiophen-2-yl group but there is no disclosure of compounds containing a morpholino-methyl group.

5 WO 99/32106 (Bayer Corporation) discloses a class of compounds of similar structure to those of WO 99/32111 for use as raf kinase inhibitors.

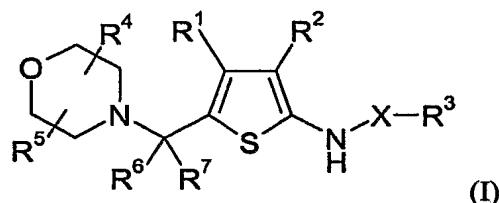
WO 99/32477 (Schering) discloses heterocyclic amide derivatives as anti-coagulants.

10 EP 0716855 & WO 95/10513 (both to Pfizer) each describe benzthiophene compounds that have estrogen agonist activity.

#### Summary of the Invention

The present invention provides a further class of compounds that have p38 MAP kinase inhibiting or modulating activity, and which it is envisaged will be useful in preventing or treating disease states or conditions mediated by the p38 MAP 15 kinases.

Accordingly, in a first aspect, the invention provides a compound of the formula (I):



wherein:

R<sup>1</sup> and R<sup>2</sup> are the same or different and each is selected from hydrogen, 20 saturated C<sub>1-3</sub> hydrocarbyl, halogen and cyano;

X is selected from C=O, C=S, C(=S)NH, C(=S)NH, C(=O)O, C(=O)S, C(=S)O and C(=S)S;

R<sup>3</sup> is selected from aryl and heteroaryl groups each having from 5 to 12 ring members and being unsubstituted or substituted by one or more substituent groups

$R^{10}$  selected from halogen, hydroxy, trifluoromethyl, cyano, nitro, carboxy, amino, mono- or di-C<sub>1-4</sub> hydrocarbyl amino, carbocyclic and heterocyclic groups having from 3 to 12 ring members; a group R<sup>a</sup>-R<sup>b</sup> wherein R<sup>a</sup> is a bond, O, CO, X<sup>1</sup>C(X<sup>2</sup>), C(X<sup>2</sup>)X<sup>1</sup>, X<sup>1</sup>C(X<sup>2</sup>)X<sup>1</sup>, S, SO, SO<sub>2</sub>, NR<sup>c</sup>, SO<sub>2</sub>NR<sup>c</sup> or NR<sup>c</sup>SO<sub>2</sub>; and R<sup>b</sup> is selected

5 from hydrogen, carbocyclic and heterocyclic groups having from 3 to 12 ring members, and a C<sub>1-8</sub> hydrocarbyl group optionally substituted by one or more substituents selected from hydroxy, oxo, halogen, cyano, nitro, carboxy, amino, mono- or di-C<sub>1-4</sub> hydrocarbyl amino, carbocyclic and heterocyclic groups having from 3 to 12 ring members and wherein one or more carbon atoms of the C<sub>1-8</sub>

10 hydrocarbyl group may optionally be replaced by O, S, SO, SO<sub>2</sub>, NR<sup>c</sup>, X<sup>1</sup>C(X<sup>2</sup>), C(X<sup>2</sup>)X<sup>1</sup> or X<sup>1</sup>C(X<sup>2</sup>)X<sup>1</sup>; or two adjacent groups R<sup>10</sup>, together with the carbon atoms or heteroatoms to which they are attached may form a 5-membered heteroaryl ring or a 5- or 6-membered non-aromatic heterocyclic ring, wherein the said heteroaryl and heterocyclic groups contain up to 3 heteroatom ring members selected from N,

15 O and S;

$R^c$  is selected from hydrogen and C<sub>1-4</sub> hydrocarbyl; and  
 $X^1$  is O, S or NR<sup>c</sup> and  $X^2$  is =O, =S or =NR<sup>c</sup>;  
 $R^4$  and  $R^5$  are the same or different and are selected from hydrogen and methyl; or one of  $R^4$  and  $R^5$  is selected from hydroxymethyl and ethyl and the other

20 is hydrogen; and  
 $R^6$  and  $R^7$  are the same or different and are selected from hydrogen and methyl.

Compounds of the formula (I) as defined above have activity in modulating or inhibiting p38 MAP kinase activity. As such, it is anticipated that the compounds

25 possessing such activity will be useful therapeutic agents in the prophylaxis or treatment of diseases where the disease or condition is one in which the activity of p38 MAP kinase initiates or facilitates development of the disease

Examples of conditions ameliorated by the inhibition of p38 MAP kinase are discussed above, and include, but are not limited to the said conditions. More

30 particularly, the conditions can be selected from:

- (i) inflammatory and arthritic diseases and conditions such as Reiter's syndrome, acute synovitis, rheumatoid arthritis, osteoarthritis, rheumatoid spondylitis, gouty arthritis, traumatic arthritis, rubella arthritis, psoriatic arthritis, graft vs. host reaction and allograft rejections;
- 5 (ii) chronic inflammatory lung diseases such as emphysema, chronic pulmonary inflammatory disease, chronic obstructive pulmonary disease (COPD), adult respiratory distress syndrome and acute respiratory distress syndrome (ARDS);
- (iii) lung diseases and conditions such as tuberculosis, silicosis, pulmonary sarcoidosis, pulmonary fibrosis and bacterial pneumonia;
- 10 (iv) inflammatory diseases and conditions of the enteric tract such as inflammatory bowel disease, Crohn's disease and ulcerative colitis;
- (v) toxic shock syndrome and related diseases and conditions such as sepsis, septic shock, endotoxic shock, gram negative sepsis and the inflammatory reaction induced by endotoxin;
- 15 (vi) Alzheimer's disease;
- (vii) reperfusion injury; and
- (viii) diseases and conditions selected from atherosclerosis; muscle degeneration; gout; cerebral malaria; bone resorption diseases; fever and myalgias due to infection, such as influenza; cachexia, in particular cachexia secondary to infection or malignancy, cachexia secondary to acquired immune deficiency syndrome (AIDS); AIDS; ARC (AIDS related complex); keloid formation; scar tissue formation; pyresis and asthma.
- 20

Of particular interest are compounds for use in the treatment or prophylaxis of inflammatory diseases and conditions, rheumatoid arthritis and osteoarthritis.

- 25 Also of particular interest are compounds for use in the treatment or prophylaxis of chronic obstructive pulmonary disease (COPD).

In another aspect, the invention provides a method for the prophylaxis or treatment of a disease state or condition of the type hereinbefore defined, which method

comprises administering to a subject (e.g. a human subject) in need thereof a compound of the formula (I) as defined herein.

Accordingly, the invention also provides a compound of the formula (I) as defined herein for use in the prophylaxis or treatment of a disease state or condition

5 mediated by a p38 MAP kinase.

In another aspect, the invention provides the use of a compound of the formula (I) as defined herein for the manufacture of a medicament for the prophylaxis or treatment of a disease state or condition mediated by a p38 MAP kinase.

In a further aspect, the invention provides a method for the prophylaxis or treatment  
10 of a disease state or condition mediated by a p38 MAP kinase, which method comprises administering to a subject (e.g. a human subject) in need thereof a compound of the formula (I) as defined herein.

The invention also provides a method of inhibiting a p38 MAP kinase, which method comprises contacting the p38 MAP kinase with a kinase-inhibiting  
15 compound of the formula (I) as defined herein.

The invention further provides a method of modulating a cellular process by inhibiting the activity of a p38 MAP kinase using a compound of the formula (I) as defined herein, which method comprises bringing the compound of formula (I) into contact with a cellular environment containing the p38 MAP kinase.

20 In a further aspect, the invention provides a compound of the formula (I) for use in medicine, for example for use in therapy.

In a further aspect, the invention provides a pharmaceutical composition comprising a compound of the formula (I) in association with a pharmaceutically acceptable carrier.

25 General Preferences and Definitions

The following general preferences and definitions shall apply to each of the moieties R<sup>1</sup> to R<sup>7</sup> and any sub-definition, sub-group or embodiment thereof, unless the context indicates otherwise.

In this specification, references to formula (I) include any sub-group (e.g. formulae 5 II, III, IV, V and VI), example or embodiment of formula (I) unless the context indicates otherwise. Thus for example, references to *inter alia* therapeutic uses, pharmaceutical formulations and processes for making compounds, where they refer to formula (I), are also to be taken as referring to any sub-group, example or embodiment of formula (I). Similarly, where preferences, embodiments and 10 examples are given for compounds of the formula (I), they are also applicable to any sub-groups or embodiments of formula (I) unless the context requires otherwise.

In the definition of the compounds of the formula (I) above and as used hereinafter, the term "hydrocarbyl" is a generic term encompassing aliphatic, alicyclic and 15 aromatic groups formed from carbon and hydrogen atoms. In certain cases, as defined herein, one or more of the carbon atoms making up the carbon backbone of the hydrocarbyl group may be replaced by a specified atom or group of atoms. Where stated, the hydrocarbyl groups may be substituted with one or more substituents as defined herein.

20 Examples of hydrocarbyl groups include saturated groups such as alkyl and cycloalkyl, and groups having varying degrees of unsaturation such as cycloalkenyl, aryl, alkenyl, alkynyl, cycloalkylalkyl, cycloalkenylalkyl, aralkyl, aralkenyl and aralkynyl groups. The examples and preferences expressed below apply to each of the hydrocarbyl substituent groups or hydrocarbyl-containing substituent groups 25 referred to in the various definitions of substituents for compounds of the formula (I) unless the context indicates otherwise.

Generally by way of example, the hydrocarbyl groups can have up to eight carbon atoms, unless the context requires otherwise. Within the sub-set of hydrocarbyl groups having 1 to 8 carbon atoms, particular examples are C<sub>1-6</sub> hydrocarbyl 30 groups, such as C<sub>1-4</sub> hydrocarbyl groups (e.g. C<sub>1-3</sub> hydrocarbyl groups or C<sub>1-2</sub>

hydrocarbyl groups), specific examples being any individual value or combination of values selected from C<sub>1</sub>, C<sub>2</sub>, C<sub>3</sub>, C<sub>4</sub>, C<sub>5</sub>, C<sub>6</sub>, C<sub>7</sub> and C<sub>8</sub> hydrocarbyl groups.

The term "alkyl" covers both straight chain and branched chain alkyl groups.

Examples of alkyl groups include methyl, ethyl, propyl, isopropyl, n-butyl, isobutyl, 5 tert-butyl, n-pentyl, 2-pentyl, 3-pentyl, 2-methyl butyl, 3-methyl butyl, and n-hexyl and its isomers. Within the sub-set of alkyl groups having 1 to 8 carbon atoms, particular examples are C<sub>1-6</sub> alkyl groups, such as C<sub>1-4</sub> alkyl groups (e.g. C<sub>1-3</sub> alkyl groups or C<sub>1-2</sub> alkyl groups).

Examples of cycloalkyl groups are those derived from cyclopropane, cyclobutane, 10 cyclopentane, cyclohexane and cycloheptane. Within the sub-set of cycloalkyl groups the cycloalkyl group will have from 3 to 8 carbon atoms, particular examples being C<sub>3-6</sub> cycloalkyl groups.

Examples of alkenyl groups include, but are not limited to, ethenyl (vinyl), 1-propenyl, 2-propenyl (allyl), isopropenyl, butenyl, buta-1,4-dienyl, pentenyl, and 15 hexenyl. Within the sub-set of alkenyl groups the alkenyl group will have 2 to 8 carbon atoms, particular examples being C<sub>2-6</sub> alkenyl groups, such as C<sub>2-4</sub> alkenyl groups.

Examples of cycloalkenyl groups include, but are not limited to, cyclopropenyl, cyclobutenyl, cyclopentenyl, cyclopentadienyl and cyclohexenyl. Within the sub-20 set of cycloalkenyl groups the cycloalkenyl groups have from 3 to 8 carbon atoms, and particular examples are C<sub>3-6</sub> cycloalkenyl groups.

Examples of alkynyl groups include, but are not limited to, ethynyl and 2-propynyl (propargyl) groups. Within the sub-set of alkynyl groups having 2 to 8 carbon atoms, particular examples are C<sub>2-6</sub> alkynyl groups, such as C<sub>2-4</sub> alkynyl groups.  
25 Examples of aryl hydrocarbyl groups include unsubstituted phenyl as well as phenyl substituted by alkyl groups, e.g. toluene, xylene and mesitylene groups

Examples of cycloalkylalkyl, cycloalkenylalkyl, carbocyclic aralkyl, aralkenyl and aralkynyl groups include phenethyl, benzyl, styryl, phenylethylynol,

cyclohexylmethyl, cyclopentylmethyl, cyclobutylmethyl, cyclopropylmethyl and cyclopentenylmethyl groups.

References to "carbocyclic" and "heterocyclic" groups as used herein, either in the context of R<sup>3</sup> and sub-definitions thereof or otherwise, shall, unless the context indicates otherwise, include both aromatic and non-aromatic ring systems. Thus, for example, the term "carbocyclic and heterocyclic groups having from 3 to 12 ring members" includes within its scope aromatic, non-aromatic, unsaturated, partially saturated and fully saturated carbocyclic and heterocyclic ring systems.

The carbocyclic or heterocyclic groups can be aryl or heteroaryl groups having from 5 to 12 ring members, more usually from 5 to 10 ring members. The term "aryl" as used herein refers to a carbocyclic group having aromatic character and the term "heteroaryl" is used herein to denote a heterocyclic group having aromatic character. The terms "aryl" and "heteroaryl" embrace polycyclic (e.g. bicyclic) ring systems wherein one or more rings are non-aromatic, provided that at least one ring is aromatic. In such polycyclic systems, the group may be attached by the aromatic ring, or to a non-aromatic ring. The aryl or heteroaryl groups can be monocyclic or bicyclic groups and can be unsubstituted or substituted with one or more substituents, for example one or more groups R<sup>10</sup> as defined herein.

The term non-aromatic group embraces unsaturated ring systems without aromatic character, partially saturated and fully saturated carbocyclic and heterocyclic ring systems. The terms "unsaturated" and "partially saturated" refer to rings wherein the ring structure(s) contains atoms sharing more than one valence bond i.e. the ring contains at least one multiple bond e.g. a C=C, C≡C or N=C bond. The terms "saturated" and "fully saturated" refer to rings where there are no multiple bonds between ring atoms. Saturated carbocyclic groups include cycloalkyl groups as defined below. Partially saturated carbocyclic groups include cycloalkenyl groups as defined below, for example cyclopentenyl, cycloheptenyl and cyclooctenyl.

Examples of heteroaryl groups are monocyclic and bicyclic groups containing from five to twelve ring members, and more usually from five to ten ring members. The heteroaryl group can be, for example, a five membered or six membered

monocyclic ring or a bicyclic structure formed from fused five and six membered rings or two fused six membered rings. Each ring may contain up to about four heteroatoms typically selected from nitrogen, sulphur and oxygen. Typically the heteroaryl ring will contain up to 3 heteroatoms, more usually up to 2, for example

5        a single heteroatom. In one embodiment, the heteroaryl ring contains at least one ring nitrogen atom. The nitrogen atoms in the heteroaryl rings can be basic, as in the case of an imidazole or pyridine, or essentially non-basic as in the case of an indole or pyrrole nitrogen. In general the number of basic nitrogen atoms present in the heteroaryl group, including any amino group substituents of the ring, will be

10      less than five.

Examples of heteroaryl groups include but are not limited to pyridine, pyrrole, furan, thiophene, imidazole, oxazole, oxadiazole, oxatriazole, isoxazole, thiazole, isothiazole, pyrazole, pyrazine, pyridazine, pyrimidine, triazine, triazole, tetrazole, quinoline, isoquinoline, benzfuran, benzthiophene, chroman, thiochroman,

15      benzimidazole, benzoxazole, benzisoxazole, benzthiazole, benzisothiazole, isobenzofuran, indole, isoindole, indolizine, indoline, isoindoline, purine (e.g., adenine, guanine), indazole, benzodioxole, chromene, isochromene, chroman, isochroman, benzodioxan, quinolizine, benzoxazine, benzodiazine, pyridopyridine, pyrazolopyridine, pyrazolopyrimidine, pyrrolopyridine, pyrrolopyrimidine,

20      quinoxaline, quinazoline, cinnoline, phthalazine, naphthyridine and pteridine groups.

Examples of polycyclic aryl and heteroaryl groups containing an aromatic ring and a non-aromatic ring include tetrahydronaphthalene, tetrahydroisoquinoline, tetrahydroquinoline, dihydrobenzthiene, dihydrobenzfuran, 2,3-dihydro-

25      benzo[1,4]dioxine, benzo[1,3]dioxole, 4,5,6,7-tetrahydrobenzofuran, indoline and indane groups.

Examples of aryl groups include phenyl, naphthyl, indenyl, and tetrahydronaphthyl groups.

Examples of non-aromatic heterocyclic groups are groups having from 3 to 12 ring members, more usually 5 to 10 ring members. Such groups can be monocyclic or

bicyclic, for example, and typically have from 1 to 5 heteroatom ring members (more usually 1, 2, 3 or 4 heteroatom ring members), usually selected from nitrogen, oxygen and sulphur. The heterocyclic groups can contain, for example, cyclic ether moieties (e.g. as in tetrahydrofuran and dioxane), cyclic thioether

- 5       moieties (e.g. as in tetrahydrothiophene and dithiane), cyclic amine moieties (e.g. as in pyrrolidine), cyclic sulphones (e.g. as in sulfolane and sulfolene), cyclic sulphoxides, cyclic sulphonamides and combinations thereof (e.g. thiomorpholine).

Particular examples include morpholine, piperidine (e.g. 1-piperidinyl, 2-piperidinyl 3-piperidinyl and 4-piperidinyl), pyrrolidine (e.g. 1-pyrrolidinyl, 2-

- 10      pyrrolidinyl and 3-pyrrolidinyl), pyrrolidone, pyran (2H-pyran or 4H-pyran), dihydrothiophene, dihydropyran, dihydrofuran, dihydrothiazole, tetrahydrofuran, tetrahydrothiophene, dioxane, tetrahydropyran (e.g. 4-tetrahydro pyranyl), imidazoline, imidazolidinone, oxazoline, thiazoline, 2-pyrazoline, pyrazolidine, piperazine, and N-alkyl piperazines such as N-methyl piperazine. In general,
- 15      preferred non-aromatic heterocyclic groups include morpholine, and N-alkyl piperazines.

Examples of non-aromatic carbocyclic groups include cycloalkane groups such as cyclohexyl and cyclopentyl, cycloalkenyl groups such as cyclopentenyl,

- 20      cyclohexenyl, cycloheptenyl and cyclooctenyl, as well as cyclohexadienyl, cyclooctatetraene, tetrahydronaphthyl and decalinyl.

Where reference is made herein to carbocyclic and heterocyclic groups, the carbocyclic or heterocyclic ring can, unless the context indicates otherwise, be unsubstituted or substituted by one or more substituent groups R<sup>10</sup> selected from

- 25      halogen, hydroxy, trifluoromethyl, cyano, nitro, carboxy, amino, mono- or di-C<sub>1-4</sub> hydrocarbyl amino, carbocyclic and heterocyclic groups having from 3 to 12 ring members; a group R<sup>a</sup>-R<sup>b</sup> wherein R<sup>a</sup> is a bond, O, CO, X<sup>1</sup>C(X<sup>2</sup>), C(X<sup>2</sup>)X<sup>1</sup>, X<sup>1</sup>C(X<sup>2</sup>)X<sup>1</sup>, S, SO, SO<sub>2</sub>, NR<sup>c</sup>, SO<sub>2</sub>NR<sup>c</sup> or NR<sup>c</sup>SO<sub>2</sub>; and R<sup>b</sup> is selected from hydrogen, carbocyclic and heterocyclic groups having from 3 to 12 ring members,
- 30      and a C<sub>1-8</sub> hydrocarbyl group optionally substituted by one or more substituents selected from hydroxy, oxo, halogen, cyano, nitro, carboxy, amino, mono- or di-

$C_{1-4}$  hydrocarbyl amino, carbocyclic and heterocyclic groups having from 3 to 12 ring members and wherein one or more carbon atoms of the  $C_{1-8}$  hydrocarbyl group may optionally be replaced by O, S, SO, SO<sub>2</sub>, NR<sup>c</sup>, X<sup>1</sup>C(X<sup>2</sup>), C(X<sup>2</sup>)X<sup>1</sup> or X<sup>1</sup>C(X<sup>2</sup>)X<sup>1</sup>; or two adjacent groups R<sup>10</sup>, together with the carbon atoms or

5 heteroatoms to which they are attached may form a 5-membered heteroaryl ring or a 5- or 6-membered non-aromatic heterocyclic ring, wherein the said heteroaryl and heterocyclic groups contain up to 3 heteroatom ring members selected from N, O and S;

R<sup>c</sup> is selected from hydrogen and  $C_{1-4}$  hydrocarbyl; and

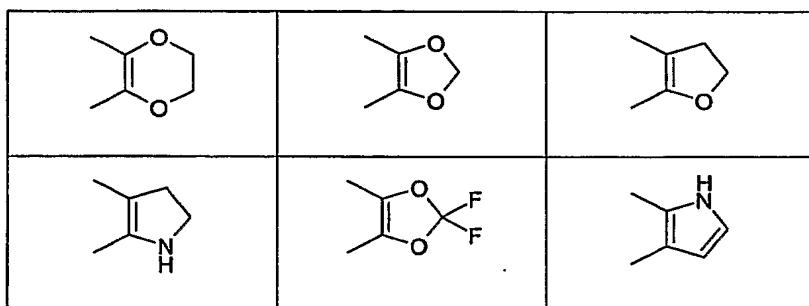
10 X<sup>1</sup> is O, S or NR<sup>c</sup> and X<sup>2</sup> is =O, =S or =NR<sup>c</sup>.

Where the substituent group R<sup>10</sup> comprises or includes a carbocyclic or heterocyclic group, the said carbocyclic or heterocyclic group may be unsubstituted or may itself be substituted with one or more further substituent groups R<sup>10</sup>. In one sub-group of compounds of the formula (I), such further substituent groups R<sup>10</sup> may include

15 carbocyclic or heterocyclic groups, which are typically not themselves further substituted. In another sub-group of compounds of the formula (I), the said further substituents do not include carbocyclic or heterocyclic groups but are otherwise selected from the groups listed above in the definition of R<sup>10</sup>.

20 Where the carbocyclic and heterocyclic groups have a pair of substituents on adjacent ring atoms, the two substituents may be linked so as to form a cyclic group. For example, an adjacent pair of substituents on adjacent carbon atoms of a ring may be linked via one or more heteroatoms and optionally substituted alkylene groups to form a fused oxa-, dioxo-, aza-, diaza- or oxa-aza-cycloalkyl group.

Examples of such linked substituent groups include:



Examples of halogen substituents include fluorine, chlorine, bromine and iodine. Fluorine and chlorine are particularly preferred.

When R<sup>b</sup> is a C<sub>1-8</sub> hydrocarbyl group, one or more carbon atoms of a hydrocarbyl group may optionally be replaced by O, S, SO, SO<sub>2</sub>, NR<sup>c</sup>, X<sup>1</sup>C(X<sup>2</sup>), C(X<sup>2</sup>)X<sup>1</sup> or X<sup>1</sup>C(X<sup>2</sup>)X<sup>1</sup> wherein X<sup>1</sup> and X<sup>2</sup> are as hereinbefore defined. For example, 1, 2, 3 or 4 carbon atoms of the hydrocarbyl group may be replaced by one of the atoms or groups listed provided that at least one carbon atom is present in the hydrocarbyl group, and the replacing atoms or groups may be the same or different. Examples of groups in which a carbon atom of the hydrocarbyl group has been replaced by a replacement atom or group as defined above include ethers and thioethers (C replaced by O or S), amides, esters, thioamides and thioesters (C replaced by X<sup>1</sup>C(X<sup>2</sup>) or C(X<sup>2</sup>)X<sup>1</sup>), sulphones and sulphoxides (C replaced by SO or SO<sub>2</sub>) and amines (C replaced by NR<sup>c</sup>).

Where an amino group has two hydrocarbyl substituents, they may, together with the nitrogen atom to which they are attached, and optionally with another heteroatom such as nitrogen, sulphur, or oxygen, link to form a ring structure of 4 to 7 ring members.

The definition "R<sup>a</sup>-R<sup>b</sup>" as used herein, either with regard to substituents present on a carbocyclic or heterocyclic moiety, or with regard to other substituents present at other locations on the compounds of the formula (I), includes *inter alia* compounds wherein R<sup>a</sup> is selected from a bond, O, CO, OC(O), SC(O), NR<sup>c</sup>C(O), OC(S), SC(S), NR<sup>c</sup>C(S), OC(NR<sup>c</sup>), SC(NR<sup>c</sup>), NR<sup>c</sup>C(NR<sup>c</sup>), C(O)O, C(O)S, C(O)NR<sup>c</sup>, C(S)O, C(S)S, C(S) NR<sup>c</sup>, C(NR<sup>c</sup>)O, C(NR<sup>c</sup>)S, C(NR<sup>c</sup>)NR<sup>c</sup>, OC(O)O, SC(O)O, NR<sup>c</sup>C(O)O, OC(S)O, SC(S)O, NR<sup>c</sup>C(S)O, OC(NR<sup>c</sup>)O, SC(NR<sup>c</sup>)O, NR<sup>c</sup>C(NR<sup>c</sup>)O, 20 OC(O)S, SC(O)S, NR<sup>c</sup>C(O)S, OC(S)S, SC(S)S, NR<sup>c</sup>C(S)S, OC(NR<sup>c</sup>)S, SC(NR<sup>c</sup>)S, NR<sup>c</sup>C(NR<sup>c</sup>)S, OC(O)NR<sup>c</sup>, SC(O)NR<sup>c</sup>, NR<sup>c</sup>C(O) NR<sup>c</sup>, OC(S)NR<sup>c</sup>, SC(S) NR<sup>c</sup>, NR<sup>c</sup>C(S)NR<sup>c</sup>, OC(NR<sup>c</sup>)NR<sup>c</sup>, SC(NR<sup>c</sup>)NR<sup>c</sup>, NR<sup>c</sup>C(NR<sup>c</sup>)NR<sup>c</sup>, S, SO, SO<sub>2</sub>, NR<sup>c</sup>, SO<sub>2</sub>NR<sup>c</sup> and NR<sup>c</sup>SO<sub>2</sub> wherein R<sup>c</sup> is as hereinbefore defined.

The moiety R<sup>b</sup> can be hydrogen or it can be a group selected from carbocyclic and heterocyclic groups having from 3 to 12 ring members (typically 3 to 10 and more

usually from 5 to 10), and a C<sub>1-8</sub> hydrocarbyl group optionally substituted as hereinbefore defined. Examples of hydrocarbyl, carbocyclic and heterocyclic groups are as set out above.

Specific Embodiments of and Preferences for R<sup>1</sup> to R<sup>7</sup>

5 In the general formula (I), the groups R<sup>1</sup> and R<sup>2</sup> are the same or different and each is selected from hydrogen, C<sub>1-3</sub> saturated hydrocarbyl, halogen and cyano.

In one group of compounds of the invention, R<sup>1</sup> is selected from hydrogen, C<sub>1-3</sub> saturated hydrocarbyl and halogen.

10 In another embodiment, R<sup>2</sup> is selected from hydrogen, C<sub>1-3</sub> saturated hydrocarbyl and halogen.

In a further embodiment, R<sup>1</sup> and R<sup>2</sup> are the same or different and each is selected from hydrogen, saturated C<sub>1-3</sub> hydrocarbyl and halogen.

In general, where R<sup>1</sup> and/or R<sup>2</sup> is/are halogen, the halogen is preferably selected from chlorine and fluorine, chlorine being particularly preferred.

15 Where R<sup>1</sup> and/or R<sup>2</sup> is/are saturated C<sub>1-3</sub> hydrocarbyl, the hydrocarbyl group can be selected from methyl, ethyl, *n*-propyl, *i*-propyl and cyclopropyl, preferred groups being methyl and ethyl, with methyl being particularly preferred.

20 In general, it is preferred that the total number of carbon, halogen and nitrogen atoms making up the substituent groups R<sup>1</sup> and R<sup>2</sup> does not exceed 5. More particularly, the total number of carbon, halogen and nitrogen atoms making up the substituent groups R<sup>1</sup> and R<sup>2</sup> is in the range 0 to 4, for example 0, 1, 2 or 3.

Typically, no more than one of the substituent groups R<sup>1</sup> and R<sup>2</sup> is a halogen.

When a halogen (particularly chlorine) or cyano group is present as one of the groups R<sup>1</sup> and R<sup>2</sup>, the other group is typically hydrogen or methyl.

25 In one group of compounds of the invention, R<sup>1</sup> is a halogen, preferably chlorine.

Particular combinations of groups R<sup>1</sup> and R<sup>2</sup> include: (a) R<sup>1</sup> = chlorine & R<sup>2</sup> = methyl; (b) R<sup>1</sup> = chlorine & R<sup>2</sup> = hydrogen; (c) R<sup>1</sup> = hydrogen & R<sup>2</sup> = hydrogen; (d) R<sup>1</sup> = methyl & R<sup>2</sup> = hydrogen; (e) R<sup>1</sup> = cyano & R<sup>2</sup> = methyl; and (f) R<sup>1</sup> = methyl & R<sup>2</sup> = cyano. A presently preferred combination is combination (a).

5 In the general formula (I), X is selected from C=O, C=S, C(=O)NH, C(=S)NH, C(=O)O, C(=O)S, C(=S)O and C(=S)S.

In one group of compounds of the invention, X is selected from C=O and C(=O)NH.

In another group of compounds of the invention, X is C(=O)NH.

10 In a further group of compounds of the invention, X is selected from C=S, C(=O)NH, C(=S)NH, C(=S)O and C(=S)S.

The group R<sup>3</sup> is selected from aryl and heteroaryl groups having from 5 to 12 ring members. It is presently preferred that the group R<sup>3</sup> is a monocyclic aryl group or a monocyclic heteroaryl group containing at least one nitrogen atom, for example up to three nitrogen atoms, preferably 0, 1 or 2 nitrogen atoms. Examples of such groups include groups selected from the monocyclic members of the list of specific heteroaryl groups set out above. Particular examples of groups R<sup>3</sup> are phenyl, pyrazolyl, and thiadiazolyl (e.g. [1,3,4]-thiadiazolyl).

15 In one sub-group of compounds of the invention, the substituent R<sup>3</sup> is a monocyclic aryl or heteroaryl group of 5 or 6 ring members wherein the aryl or heteroaryl group bears a substituent group which is a 4-7 membered carbocyclic and heterocyclic group. The carbocyclic or heterocyclic substituent can be linked to the aryl or heteroaryl group via a carbon-nitrogen bond.

20 The carbon atom of the carbon-nitrogen bond can form part of the aryl or heteroaryl group, or the carbon atom of the carbon-nitrogen bond can form part of the substituent group.

When the carbon atom of the carbon-nitrogen bond forms part of the substituent group, the substituent group can be for example an optionally substituted phenyl ring attached to the heteroaryl group via a nitrogen atom in the heteroaryl group. The optional substituents on the phenyl ring may be selected from the list set out 5 above in relation to R<sup>10</sup>. A preferred substituent is fluoro, for example *para*-fluoro.

When the nitrogen atom of the carbon-nitrogen bond forms part of the substituent group, the substituent group can be, for example, a 4 to 7 membered (more typically 5 to 6 membered) heterocyclic group R<sup>8</sup> containing at least one nitrogen atom. Preferred heterocyclic groups in this context include morpholino, piperidino, 10 piperazino, N-methyl piperazino and pyrrolidino, with morpholino being particularly preferred.

Where the group R<sup>3</sup> is a phenyl group, it can be optionally substituted by one or more substituents R<sup>10</sup> as hereinbefore defined. One sub-group of compounds is the group of compounds wherein the phenyl ring contains one or two *meta* substituents, 15 for example wherein one *meta* position on the phenyl ring is unsubstituted or is substituted by a group selected from fluorine, chlorine, methoxy, trifluoromethoxy, trifluoromethyl, ethyl, methyl and isopropyl; and the other *meta* position is substituted by a group selected from fluorine, chlorine, methoxy, trifluoromethoxy, trifluoromethyl, ethyl, methyl, isopropyl, isobutyl, t-butyl, phenyl, substituted 20 phenyl, and five and six membered monocyclic heterocyclic groups.

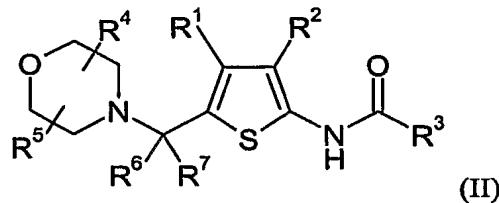
One particular combination of *meta* substituents is the combination of a halogen, preferably fluoro, and a group R<sup>8</sup> as hereinbefore defined.

Where the group R<sup>3</sup> is a heteroaryl group, it can be, for example, a pyrazole group optionally substituted by one or more substituents R<sup>7</sup> as hereinbefore defined. The 25 pyrazole group can have, for example, one or two such substituent groups R<sup>7</sup>. Where there are two substituent groups R<sup>7</sup> present, it is preferred that they are located on non-adjacent ring members. It is further preferred that at least one of the substituents is located at a position *meta* or β with respect to the ring member linked to the group X.

One particularly preferred group of compounds is the group wherein the heteroaryl group R<sup>3</sup> is a pyrazolyl ring substituted by an optionally substituted phenyl group (e.g. 4-fluorophenyl) and a C<sub>1-4</sub> hydrocarbyl group, e.g. a *tert*-butyl group or a *tert*-butyl isostere.

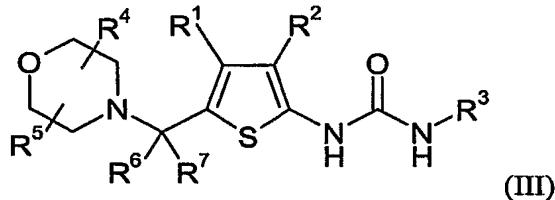
5 Another particularly preferred group of compounds is the group wherein the heteroaryl group R<sup>3</sup> is a thiadiazole group (e.g. a [1,3,4]-thiadiazole group).

One group of compounds of the invention is defined by the general formula (II);



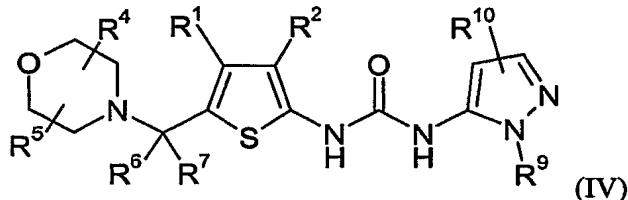
wherein R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup>, R<sup>6</sup> and R<sup>7</sup> are as hereinbefore defined.

10 Another group of compounds of the invention is represented by the formula (III):



wherein R<sup>1</sup> to R<sup>7</sup> are as hereinbefore defined.

Within the group of compounds of the formula (III) are compounds of the formula (IV):



15

wherein R<sup>1</sup>, R<sup>2</sup> and R<sup>4</sup> are as hereinbefore defined;

R<sup>9</sup> is selected from carbocyclic and heterocyclic groups having from 3 to 7 ring members; a group R<sup>e</sup>-R<sup>f</sup> wherein R<sup>e</sup> is a bond, CO, X<sup>1</sup>C(X<sup>2</sup>), C(X<sup>2</sup>)X<sup>1</sup>,

$X^1C(X^2)X^1$ , SO,  $SO_2$ ,  $SO_2NR^c$  or  $NR^cSO_2$ ; and  $R^f$  is selected from (a) hydrogen, (b) carbocyclic and heterocyclic groups having from 3 to 7 ring members, and (c) a  $C_{1-8}$  hydrocarbyl group optionally substituted by one or more substituents selected from hydroxy, oxo, halogen, cyano, nitro, amino, mono- or di- $C_{1-4}$  hydrocarbylamino,

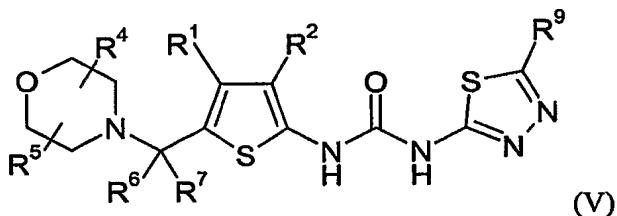
5 and carbocyclic and heterocyclic groups having from 3 to 7 ring members and wherein one or more carbon atoms of the  $C_{1-8}$  hydrocarbyl group may optionally be replaced by O, S, SO,  $SO_2$ ,  $NR^c$ ,  $X^1C(X^2)$ ,  $C(X^2)X^1$  or  $X^1C(X^2)X^1$ ; where  $X^1$ ,  $X^2$  and  $R^c$  are as hereinbefore defined; and

$R^{10}$  is selected from hydrogen, halogen and  $C_{1-6}$  hydrocarbyl optionally

10 substituted by one or more substituents selected from hydroxy, oxo, halogen, cyano, nitro, and wherein one or more carbon atoms of the  $C_{1-6}$  hydrocarbyl group may optionally be replaced by O, S, SO,  $SO_2$ ,  $NR^c$ ,  $X^1C(X^2)$ ,  $C(X^2)X^1$  or  $X^1C(X^2)X^1$ ; where  $X^1$ ,  $X^2$  and  $R^c$  are as hereinbefore defined.

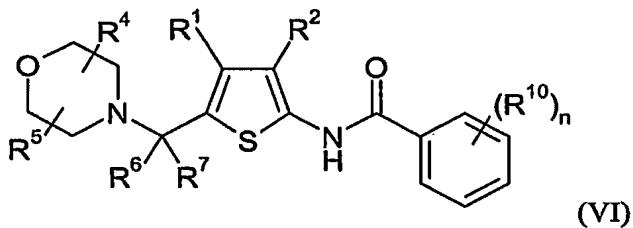
In the group of compounds defined by formula (IV),  $R^9$  is preferably a phenyl group, for example a fluorophenyl group (e.g. a 4-fluorophenyl group); and  $R^{10}$  is preferably a hydrogen atom or a  $C_{1-6}$  alkyl group, particular examples of which are methyl, ethyl, propyl, isopropyl, butyl, isobutyl and tertiary butyl; with tertiary butyl being particularly preferred.

A further group of compounds within the general formula (III) is the group of  
20 compounds of the formula (V):



wherein  $R^{11}$  is  $R^6$  or  $NHR^5$ ; and  $R^1$ ,  $R^2$ ,  $R^5$ ,  $R^6$  and  $R^9$  are as hereinbefore defined.

Another group of novel compounds of the formula (II) is defined by formula (VI):



where R<sup>1</sup>, R<sup>2</sup>, R<sup>4</sup> to R<sup>7</sup> and R<sup>10</sup> are as hereinbefore defined and n is 0-3, preferably 0-2, and more preferably 1 or 2.

In one general embodiment, it is preferred that when X is C=O or C=S and R<sup>3</sup> bears  
 5 a substituent group R<sup>a</sup>-R<sup>b</sup> attached to an atom adjacent the atom in R<sup>3</sup> to which X is attached, and R<sup>b</sup> is a carbocyclic or heterocyclic group or C<sub>1-8</sub> hydrocarbyl substituted by a carbocyclic or heterocyclic group, then R<sup>a</sup> is selected from a bond, O, CO, X<sup>1</sup>C(X<sup>2</sup>)X<sup>1</sup>, S, SO and SO<sub>2</sub>.

In another general embodiment, it is preferred that when X is CO, R<sup>3</sup> is other than a  
 10 fused bicyclic aromatic or partially aromatic group bearing a substituent on a ring atom adjacent the ring atom to which X is attached.

For the avoidance of doubt, it is to be understood that each general and specific preference, embodiment and example of any one group selected from R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>  
 15 R<sup>4</sup>, R<sup>5</sup>, R<sup>6</sup>, R<sup>7</sup>, R<sup>8</sup>, R<sup>9</sup> and R<sup>10</sup> and sub-groups thereof may be combined with each general and specific preference, embodiment and example of any one or more other groups selected from R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup> R<sup>4</sup>, R<sup>5</sup>, R<sup>6</sup>, R<sup>7</sup>, R<sup>8</sup>, R<sup>9</sup> and R<sup>10</sup> and sub-groups thereof and that all such combinations are embraced by this application.

The various functional groups and substituents making up the compounds of the formula (I) are typically chosen such that the molecular weight of the compound of  
 20 the formula (I) does not exceed 1000. More usually, the molecular weight of the compound will be less than 750, for example less than 700, or less than 650, or less than 600, or less than 550. More preferably, the molecular weight is less than 525 and, for example, is 500 or less.

Specific examples of novel compounds within the scope of the present invention  
 25 include:

N-(4-chloro-3-methyl-5-(morpholin-yl methyl-thiophen-2-yl)-3-fluoro-morpholin-4-yl-benzamide;

1-[5-tert-butyl-2(4-fluoro-phenyl)-2H-pyrazol-3-yl]-3-(4-chloro-3-methyl-5-morpholin-4-ylmethyl-thiophen-2-yl) urea;

5 1-[5-tert-butyl-2-(2,4-difluoro-phenyl)-2H-pyrazol-3-yl]-3-(4-chloro-3-methyl-5-morpholin-4-ylmethyl-thiophen-2-yl)-urea; and

1-(4-chloro-3-methyl-5-morpholin-4-ylmethyl-thiophen-2-yl)-3-[5-(tetrahydro-furan-2-yl)-[1,3,4]thiadiazol-2-yl]-urea.

Particular compounds of the invention are as illustrated in the examples below.

10 Many compounds of the formula (I) can exist in the form of salts, for example acid addition salts or, in certain cases salts of organic and inorganic bases such as carboxylate, sulphonate and phosphate salts. All such salts are within the scope of this invention, and references to compounds of the formula (I) include the salt forms of the compounds.

15 Acid addition salts may be formed with a wide variety of acids, both inorganic and organic. Examples of acid addition salts include salts formed with hydrochloric, hydriodic, phosphoric, nitric, sulphuric, citric, lactic, succinic, maleic, malic, isethionic, fumaric, benzenesulphonic, toluenesulphonic, methanesulphonic, ethanesulphonic, naphthalenesulphonic, valeric, acetic, propanoic, butanoic,

20 malonic, glucuronic and lactobionic acids.

For example, if the compound is anionic, or has a functional group which may be anionic (e.g., -COOH may be -COO<sup>-</sup>), then a salt may be formed with a suitable cation. Examples of suitable inorganic cations include, but are not limited to, alkali metal ions such as Na<sup>+</sup> and K<sup>+</sup>, alkaline earth cations such as Ca<sup>2+</sup> and Mg<sup>2+</sup>, and other cations such as Al<sup>3+</sup>. Examples of suitable organic cations include, but are not limited to, ammonium ion (i.e., NH<sub>4</sub><sup>+</sup>) and substituted ammonium ions (e.g., NH<sub>3</sub>R<sup>+</sup>, NH<sub>2</sub>R<sub>2</sub><sup>+</sup>, NHR<sub>3</sub><sup>+</sup>, NR<sub>4</sub><sup>+</sup>). Examples of some suitable substituted ammonium ions are those derived from: ethylamine, diethylamine, dicyclohexylamine, triethylamine, butylamine, ethylenediamine, ethanolamine, diethanolamine,

piperazine, benzylamine, phenylbenzylamine, choline, meglumine, and tromethamine, as well as amino acids, such as lysine and arginine. An example of a common quaternary ammonium ion is  $\text{N}(\text{CH}_3)_4^+$ .

Where the compounds of the formula (I) contain an amine function, these may form  
 5 quaternary ammonium salts, for example by reaction with an alkylating agent according to methods well known to the skilled person. Such quaternary ammonium compounds are within the scope of formula (I).

Compounds of the formula (I) containing an amine function may also form N-  
 10 oxides. A reference herein to a compound of the formula (I) that contains an amine function also includes the N-oxide.

Where a compound contains several amine functions, one or more than one nitrogen atom may be oxidised to form an N-oxide. Particular examples of N-oxides are the N-oxides of a tertiary amine or a nitrogen atom of a nitrogen-containing heterocycle.

15 N-Oxides can be formed by treatment of the corresponding amine with an oxidizing agent such as hydrogen peroxide or a per-acid (e.g. a peroxy carboxylic acid), see for example *Advanced Organic Chemistry*, by Jerry March, 4<sup>th</sup> Edition, Wiley Interscience, pages. More particularly, N-oxides can be made by the procedure of L. W. Deady (*Syn. Comm.* 1977, 7, 509-514) in which the amine compound is  
 20 reacted with *m*-chloroperoxybenzoic acid (MCPBA), for example, in an inert solvent such as dichloromethane.

Compounds of the formula may exist in a number of different geometric isomeric, and tautomeric forms and references to compounds of the formula (I) include all such forms. For the avoidance of doubt, where a compound can exist in one of  
 25 several geometric isomeric or tautomeric forms and only one is specifically described or shown, all others are nevertheless embraced by formula (I).

Esters such as carboxylic acid esters and acyloxy esters of the compounds of formula (I) bearing a carboxylic acid group or a hydroxyl group are also embraced by Formula (I). Examples of esters are compounds containing the group

-C(=O)OR, wherein R is an ester substituent, for example, a C<sub>1-7</sub> alkyl group, a C<sub>3-20</sub> heterocyclyl group, or a C<sub>5-20</sub> aryl group, preferably a C<sub>1-7</sub> alkyl group. Particular examples of ester groups include, but are not limited to, -C(=O)OCH<sub>3</sub>, -C(=O)OCH<sub>2</sub>CH<sub>3</sub>, -C(=O)OC(CH<sub>3</sub>)<sub>3</sub>, and -C(=O)OPh. Examples of acyloxy (reverse ester) groups are represented by -OC(=O)R, wherein R is an acyloxy substituent, for example, a C<sub>1-7</sub> alkyl group, a C<sub>3-20</sub> heterocyclyl group, or a C<sub>5-20</sub> aryl group, preferably a C<sub>1-7</sub> alkyl group. Particular examples of acyloxy groups include, but are not limited to, -OC(=O)CH<sub>3</sub> (acetoxy), -OC(=O)CH<sub>2</sub>CH<sub>3</sub>, -OC(=O)C(CH<sub>3</sub>)<sub>3</sub>, -OC(=O)Ph, and -OC(=O)CH<sub>2</sub>Ph.

5      10     Also encompassed by formula (I) are any polymorphic forms of the compounds, solvates (e.g. hydrates), complexes (e.g. inclusion complexes or clathrates with compounds such as cyclodextrins, or complexes with metals) of the compounds, and pro-drugs of the compounds. By "prodrugs" is meant for example any compound that is converted *in vivo* into a biologically active compound of the

15    formula (I).

For example, some prodrugs are esters of the active compound (e.g., a physiologically acceptable metabolically labile ester). During metabolism, the ester group (-C(=O)OR) is cleaved to yield the active drug. Such esters may be formed by esterification, for example, of any of the carboxylic acid groups (-C(=O)OH) in

20    the parent compound, with, where appropriate, prior protection of any other reactive groups present in the parent compound, followed by deprotection if required.

Examples of such metabolically labile esters include those of the formula - C(=O)OR wherein R is:

C<sub>1-7</sub> alkyl (e.g., Me, Et, *n*-Pr, *i*-Pr, *n*-Bu, *s*-Bu, *i*-Bu, *t*-Bu);

25    C<sub>1-7</sub> aminoalkyl (e.g., aminoethyl; 2-(N,N-diethylamino)ethyl; 2-(4-morpholino)ethyl); and

acyloxy-C<sub>1-7</sub> alkyl (e.g., acyloxymethyl; acyloxyethyl; pivaloyloxymethyl; acetoxyethyl; 1-acetoxyethyl; 1-(1-methoxy-1-methyl)ethyl-carbonyloxyethyl; 1-(benzoyloxy)ethyl; isopropoxy-carbonyloxymethyl; 1-isopropoxy-

30    carbonyloxyethyl; cyclohexyl-carbonyloxymethyl; 1-cyclohexyl-carbonyloxyethyl;

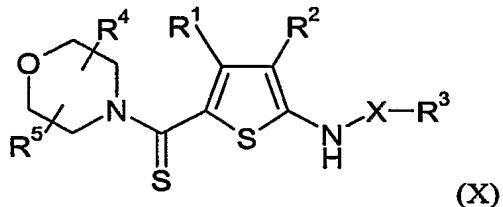
cyclohexyloxy-carbonyloxymethyl; 1-cyclohexyloxy-carbonyloxyethyl; (4-tetrahydropyranloxy) carbonyloxymethyl; 1-(4-tetrahydropyranloxy)-carbonyloxyethyl; (4-tetrahydropyranyl)carbonyloxymethyl; and 1-(4-tetrahydro-pyranyl)carbonyloxyethyl).

- 5 Also, some prodrugs are activated enzymatically to yield the active compound, or a compound which, upon further chemical reaction, yields the active compound (for example, as in Antibody-directed Enzyme Prodrug Therapy (ADEPT), Gene-directed Enzyme Prodrug Therapy (GDEPT), Polymer-directed Enzyme Prodrug Therapy (PDEPT), Ligand-directed Enzyme Prodrug Therapy (LIDEP), etc.). For
- 10 example, the prodrug may be a sugar derivative or other glycoside conjugate, or may be an amino acid ester derivative.

Where the compounds of the formula (I) contain chiral centres, all individual optical forms such as enantiomers, epimers and diastereoisomers, as well as racemic mixtures of the compounds are within the scope of formula (I).

**15 Methods for the Preparation of Compounds of the Formula (I)**

Compounds of the formula (I) wherein R<sup>6</sup> and R<sup>7</sup> are hydrogen can be prepared by the S-alkylation (e.g. methylation) of a compound of the formula (X):

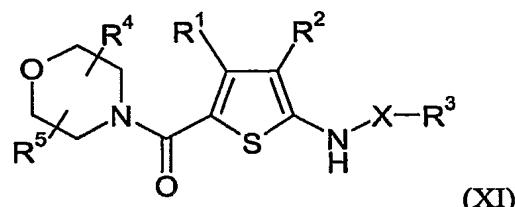


- using an alkylating agent such as methyl iodide to give a thioimide intermediate
- 20 (not shown) which can then be reduced to the compound of formula (I) by means of a reducing agent such as a borohydride, preferably an alkali metal borohydride, e.g. sodium borohydride. The reduction of the thioimide is typically carried out at ambient temperatures in an alcohol solvent such as methanol.

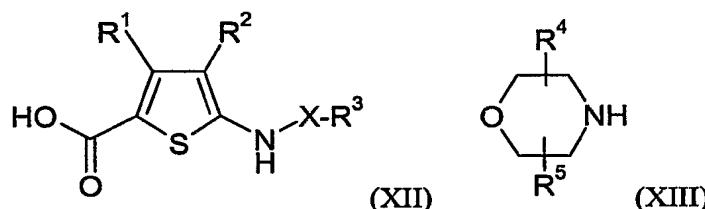
- Alternatively, by treating the thioimide intermediate with (i) methyl lithium or
- 25 methylmagnesium bromide, followed by sodium borohydride, or (ii) two

equivalents of methyl lithium or methylmagnesium bromide, using conditions analogous to those described in Arnat *et al.*, *J. Org. Chem.*, (2003) 1919-1928, Vol. 68, No. 5, compounds of the formula (I) in which R<sup>6</sup> and/or R<sup>7</sup> are methyl groups can be prepared.

5 The thioamide compound (X) can be prepared by the selective thionation of the morpholine-amide group in a compound of the formula (XI):



using a thionating agent such as phosphorus pentasulphide ( $P_2S_5$ ) or a derivative thereof such as Lawesson's reagent under standard thionation conditions. The amide (XII) can be prepared by reacting a carboxylic acid of the formula (XII):



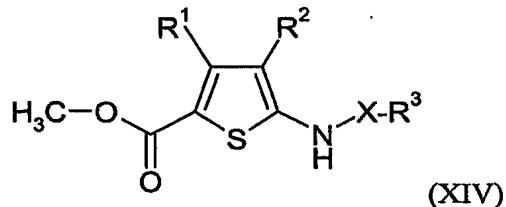
or an activated derivative thereof, with an optionally substituted morpholine compound of the formula (XIII).

The coupling reaction between the morpholine compound (XIII) and the carboxylic acid (XII) can be carried out by forming an activated derivative of the acid such as an acid chloride (e.g. by reaction with thionyl chloride), and then reacting the acid chloride with the amine, for example by the method described in *Zh. Obs. Khim.* 31, 201 (1961), and the method described in US 3,705,175. Alternatively, acid chlorides can be formed by reacting the acid with oxalyl chloride the presence of dimethyl formamide, or by forming the carboxylate salt and reacting the salt with oxalyl chloride.

Alternatively, and more preferably, the coupling reaction between the carboxylic acid (XII) and the morpholine compound (XIII) can be carried out in the presence of an amide coupling reagent of the type commonly used to form peptide linkages. Examples of such reagents include 1,3-dicyclohexylcarbodiimide (DCC) (Sheehan et al, J. Amer. Chem Soc. 1955, 77, 1067), 1-ethyl-3-(3'-dimethylaminopropyl)-carbodiimide (EDAC) (Sheehan et al, J. Org. Chem., 1961, 26, 2525), uronium-based coupling agents such as *O*-(7-azabenzotriazol-1-yl)-*N,N,N',N'*-tetramethyluronium hexafluorophosphate (HATU) and phosphonium-based coupling agents such as 1-benzo-triazolyloxytris-(pyrrolidino)phosphonium hexafluorophosphate (PyBOP) (Castro et al, Tetrahedron Letters, 1990, 31, 205). Carbodiimide-based coupling agents are advantageously used in combination with 1-hydroxy-7-azabenzotriazole (HOAt) (L. A. Carpino, J. Amer. Chem. Soc., 1993, 115, 4397) or 1-hydroxybenzotriazole (HOBT) (Konig et al, Chem. Ber., 103, 708, 2024-2034). Preferred coupling reagents include EDC and DCC in combination with HOAt or HOBT.

The coupling reaction is typically carried out in a non-aqueous, non-protic solvent such as dimethylsulfoxide, dichloromethane, dimethylformamide or N-methylpyrrolidine. The reaction can be carried out at room temperature or, where the reactants are less reactive (for example in the case of electron-poor anilines bearing electron withdrawing groups such as sulphonamide groups) at an appropriately elevated temperature. The reaction may be carried out in the presence of a non-interfering base, for example a tertiary amine such as triethylamine or *N,N*-diisopropylethylamine.

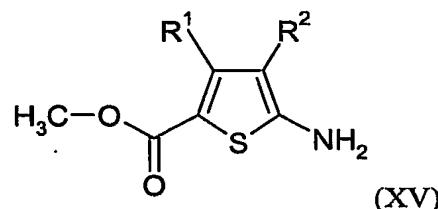
Compounds of the formula (XII) can be prepared by hydrolysis of a compound of the formula (XIV):



wherein R<sup>1</sup> to R<sup>3</sup> are as hereinbefore defined. The hydrolysis reaction can be effected using standard methods, for example by treatment with an alkali metal hydroxide such as lithium hydroxide. The reaction is typically carried out in an aqueous solvent, optionally in the presence of a miscible co-solvent such as

5 methanol or ethanol with heating to a non-extreme temperature between room temperature and 100°C, preferably a temperature below 80°C.

Compounds of the formula (XIV) in which X is CO can be prepared from compounds of the formula (XV):



10 by reaction with a compound of the formula R<sup>3</sup>COOH or an activated derivative thereof such as an acid chloride in accordance with standard methods. Thus, for example, an acid chloride can be generated using oxalyl chloride and dimethylformamide in a non-protic solvent such as dichloromethane. Alternatively, coupling of the amine and carboxylic acid can be effected using one or more of the

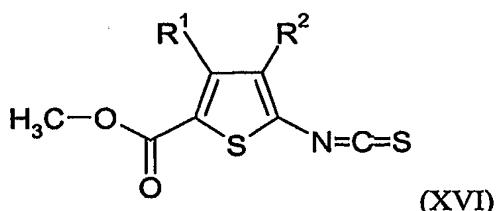
15 peptide coupling reagents described above.

Compounds of the formula (XIV) in which X is CONH, C(O)O and C(O)S can be prepared by reaction of a compound of the formula (VII) with a compound of the formula R<sup>3</sup>NH<sub>2</sub>, R<sup>3</sup>OH, or R<sup>3</sup>SH and phosgene. The reaction is typically carried out in a non protic solvent such as dichloromethane or toluene, for example at a

20 moderate temperature such as room temperature.

Compounds of the formula (XIV) in which X is C(=S)NH can be prepared by reacting a compound of the formula (XV) with an isothiocyanate R<sup>3</sup>NCS according to standard methods. Compounds of the formula (XIV) in which X is C(=S), C(=S)NH, C(=S)O and C(=S)S can be prepared from compounds of the formula

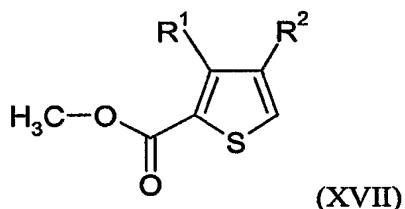
25 (XVI):



by reaction with a compound of the formula  $R^3NH_2$ ,  $R^3O$  or  $R^3SO$  in accordance with standard methods. Examples of such methods can be found in *Synthesis*, Vol. 1, pp108-118 (2001), *Heterocyclic Chemistry*, Vol. 17(8), pp 1789-92 (1980) and  
 5 *Zh. Org. Khim.* Vol. 12(7), pp 1532-1535 (1976).

Compounds of the formula (XVI) can be prepared from the corresponding amine (XV) by reaction with thiophosgene, for example as described in Kryczka *et al.*, *Organiki*, pp65-72, 2001 and Grayson, *Organic Process Research & Development*, Vol. 1(3), pp240-246 (1997).

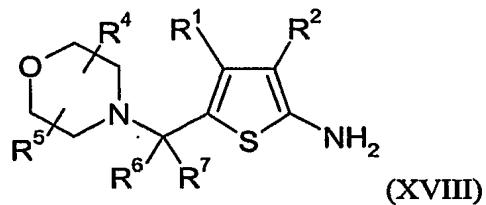
10 Compounds of the formula (XV) are commercially available or can be prepared by nitration and reduction of a compound of the formula (XVII):



Nitration of the compound of the formula (XVII) can be achieved using standard conditions well known to the skilled chemist. For example, the compound of the  
 15 formula (XVII) can be reacted with acetic acid and nitric acid in acetic anhydride, in the presence of a co-solvent, e.g. a halogenated hydrocarbon such as dichloromethane. Where required, the reaction mixture may be heated, for example to a temperature of up to about 100°C, more preferably up to about 80°C.

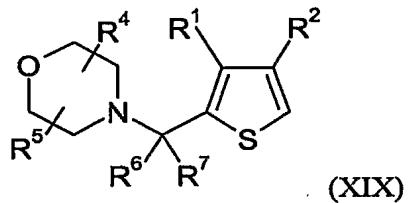
The resulting nitro-intermediate is reduced to give the amine using a suitable  
 20 reducing agent. Thus, for example, reduction can be effected using a mixture of powdered iron and iron sulphate in an aqueous solvent optionally containing a water-miscible co-solvent such as dioxane.

Compounds of the formula (I) in which X is C(=O)NH can be prepared by reacting a compound of the formula (X):



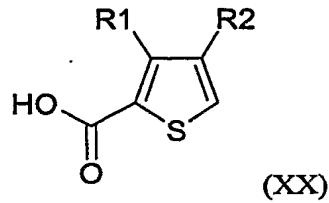
with phosgene and subsequently with a compound of the formula R<sup>3</sup>NH<sub>2</sub>. The  
5 reaction is typically carried out in a dry aprotic solvent such as dichloromethane at a  
non-extreme temperature, for example at room temperature.

Compounds of the formula (XVIII) can be prepared by nitration of a compound of the formula (XIX) and subsequent reduction of the nitro group to an amino group.



10 Nitration can be carried out using nitration conditions known to be suitable for  
nitrating thiophenes. For example, nitration may be effected using a nitronium salt  
such as nitronium tetrafluoroborate in a polar aprotic solvent such as acetonitrile.  
The reaction is typically carried out ambient temperatures or lower.

15 The compounds of the formula (XIX) can be prepared by reacting a carboxylic acid  
of the formula (XX) with a morpholine compound of the formula (XIII) using the  
methods of amide formation described above.



### **Novel Chemical Intermediates**

Some of the intermediate compounds (in particular the thioamide compounds of the formula (X) above) used in the synthesis of the compounds of the formula (I) are novel and, as such, represent a further aspect of the invention.

### **5    Pharmaceutical Formulations**

The invention also provides compounds of the formula (I) as hereinbefore defined in the form of pharmaceutical compositions.

The pharmaceutical compositions can be in any form suitable for oral, parenteral, topical, intranasal, intra-articular, ophthalmic, otic, rectal, intra-vaginal, or  
10 transdermal administration, or administration by inhalation. Where the compositions are intended for parenteral administration, they can be formulated for intravenous, intramuscular or subcutaneous administration.

15 Pharmaceutical dosage forms suitable for oral administration include tablets, capsules, caplets, pills, lozenges, syrups, solutions, powders, granules, elixirs and suspensions, sublingual tablets, wafers or patches and buccal patches.

Pharmaceutical compositions containing compounds of the formula (I) can be formulated in accordance with known techniques, see for example, Remington's Pharmaceutical Sciences, Mack Publishing Company, Easton, PA, USA.

Thus, tablet compositions can contain a unit dosage of active compound together  
20 with an inert diluent or carrier such as a sugar or sugar alcohol, eg; lactose, sucrose, sorbitol or mannitol; and/or a non-sugar derived diluent such as sodium carbonate, calcium phosphate, calcium carbonate, or a celluloses or derivative thereof such as methyl cellulose, ethyl cellulose, hydroxypropyl methyl cellulose, and starches such as corn starch. Tablets may also contain such standard ingredients as binding and  
25 granulating agents agents such as polyvinylpyrrolidone, disintegrants (e.g. swellable crosslinked polymers such as crosslinked carboxymethylcellulose), lubricating agents (e.g. stearates), preservatives (e.g. parabens), antioxidants (e.g. BHT), buffering agents (for example phosphate or citrate buffers), and effervescent

agents such as citrate/bicarbonate mixtures. Such excipients are well known and do not need to be discussed in detail here.

Capsule formulations may be of the hard gelatin or soft gelatin variety and can contain the active component in solid, semi-solid, or liquid form. Gelatin capsules

5 can be formed from animal gelatin or synthetic or plant derived equivalents thereof.

The solid dosage forms (e.g. tablets, capsules etc.) can be coated or un-coated, but typically have a coating, for example a protective film coating (e.g. a wax or varnish) or a release controlling coating. The coating (e.g. a Eudragit <sup>TM</sup> type polymer) can be designed to release the active component at a desired location

10 within the gastro-intestinal tract. Thus, the coating can be selected so as to degrade under certain pH conditions within the gastrointestinal tract, thereby selectively release the compound in the stomach or in the ileum or duodenum.

Instead of, or in addition to, a coating, the drug can be presented in a solid matrix comprising a release controlling agent, for example a release delaying agent which

15 may be adapted to selectively release the compound under conditions of varying acidity or alkalinity in the gastrointestinal tract. Alternatively, the matrix material or release retarding coating can take the form of an erodible polymer (e.g. a maleic anhydride polymer) which is substantially continuously eroded as the dosage form passes through the gastrointestinal tract.

20 Compositions for topical use include ointments, creams, sprays, patches, gels, liquid drops and inserts (for example intraocular inserts). Such compositions can be formulated in accordance with known methods.

Compositions for parenteral or intra-articular administration are typically presented as sterile aqueous or oily solutions or fine suspensions, or may be provided in finely divided sterile powder form for making up extemporaneously with sterile water for injection.

Examples of formulations for rectal or intra-vaginal administration include foams, pessaries and suppositories which may be, for example, formed from a shaped moldable or waxy material containing the active compound.

Compositions for administration by inhalation may take the form of inhalable powder compositions or liquid or powder sprays, and can be administrated in standard form using powder inhaler devices or aerosol dispensing devices. Such devices are well known. For administration by inhalation, the powdered

5 formulations typically comprise the active compound together with an inert solid powdered diluent such as lactose.

The compounds of the inventions will generally be presented in unit dosage form and, as such, will typically contain sufficient compound to provide a desired level of biological activity. For example, a formulation intended for oral administration  
10 may contain from 0.1 milligrams to 2 grams of active ingredient, more usually from 10 milligrams to 1 gram, for example, 50 milligrams to 500 milligrams.

The active compound will be administered to a patient in need thereof (for example a human or animal patient) in an amount sufficient to achieve the desired therapeutic effect.

15 **Methods of Treatment**

It is envisaged that the compounds of the formula (I) will useful in the prophylaxis or treatment of a range of disease states or conditions mediated by p38 MAP kinases. Examples of such disease states and conditions are set out above.

Compounds of the formula (I) are generally administered to a subject in need of  
20 such administration, for example a human or animal patient, preferably a human.

The compounds will typically be administered in amounts that are therapeutically or prophylactically useful and which generally are non-toxic. However, in certain situations (for example in the case of life threatening diseases), the benefits of administering a compound of the formula (I) may outweigh the disadvantages of  
25 any toxic effects or side effects, in which case it may be considered desirable to administer compounds in amounts that are associated with a degree of toxicity.

A typical daily dose of the compound can be in the range from 100 picograms to 10 milligrams per kilogram of body weight, more typically 10 nanograms to 1

milligram per kilogram of bodyweight although higher or lower doses may be administered where required. Ultimately, the quantity of compound administered will be commensurate with the nature of the disease or physiological condition being treated and will be at the discretion of the physician.

- 5 The compounds of the formula (I) can be administered as the sole therapeutic agent or they can be administered in combination therapy with one or more other compounds for treatment of a particular disease state, for example rheumatoid arthritis, osteoarthritis, chronic lung inflammatory diseases (e.g. COPD) and inflammatory bowel diseases. Examples of other therapeutic agents that may be
- 10 administered together (whether concurrently or at different time intervals) with the compounds of the formula (I) include methotrexate, prednisilone, sulfasalazine, leflunomide and NSAIDs, for example COX-2 inhibitors such as celecoxib, rofecoxib, valdecoxib and lumiracoxib, bronchodilators, e.g. beta agonists and anticholinergics such as salbutamol, salmeterol and ipatropium bromide;
- 15 corticosteroids such as fluticasone propionate; mucolytics such as guaifenesin; and antibiotics.

#### **EXAMPLES**

The invention will now be illustrated, but not limited, by reference to the specific embodiments described in the following examples.

- 20 In the examples, the compounds prepared were characterised by liquid chromatography and mass spectroscopy using two systems, the details of which are set out below. The two systems were equipped with identical chromatography columns and were set up to run under the same operating conditions. The operating conditions used are also described below.

- 25 **1. Platform system**

System: Waters 2790/Platform LC

Mass Spec Detector: Micromass Platform LC

PDA Detector: Waters 996 PDA

**Analytical conditions:**

P035 (US)

Eluent A: H<sub>2</sub>O (1% Formic Acid)

Eluent B: CH<sub>3</sub>CN (1% Formic Acid)

Gradient: 5-95% eluent B

Flow: 1.5 ml/min

5 Column: Synergi 4μm Max-RP C<sub>12</sub>, 80A, 50 x 4.6 mm (Phenomenex)

**MS conditions:**

Capillary voltage: 3.5 kV

Cone voltage: 30 V

Source Temperature: 120

10 **2. FractionLynx system**

System: Waters FractionLynx (dual analytical/prep)

Mass Spec Detector: Waters-Micromass ZQ

PDA Detector: Waters 2996 PDA

**Analytical conditions:**

15 Eluent A: H<sub>2</sub>O (1% Formic Acid)

Eluent B: CH<sub>3</sub>CN (1% Formic Acid)

Gradient: 5-95% eluent B

Flow: 1.5 ml/min

Column: Synergi 4μm Max-RP C<sub>12</sub>, 80A, 50 x 4.6 mm (Phenomenex)

20 **MS conditions:**

Capillary voltage: 3.5 kV

Cone voltage: 30 V

Source Temperature: 120

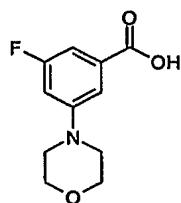
Desolvation Temperature: 230

25 The starting materials for each of the Examples are commercially available unless otherwise specified.

**EXAMPLE 1**

Preparation of N-(4-Chloro-3-methyl-5-(morpholin-yl methyl-thiophen-2-yl)-3-fluoro-morpholin-4-yl-benzamide

1A. Preparation of 3-fluoro-5-morpholin-4-yl-benzoic acid



5 To a solution of 3,5-di-fluorobenzoic acid (commercially available) (10 g, 63.3 mmol) in ethanol (100 ml) was added concentrated sulphuric acid (5 ml) and the reaction was heated at 80 °C for 48 hours. The reaction mixture was evaporated and the residue was partitioned between ethyl acetate and 2N sodium hydroxide. The organic layer was washed with saturated brine solution, dried ( $\text{MgSO}_4$ ), filtered and evaporated to afford 3,5-di-fluorobenzoic acid ethyl ester as a pale yellow oil (8.79 g) which was used immediately in the next step without purification;  $\delta_{\text{H}}$  (400 MHz,  $\text{CDCl}_3$ ) 7.6 (m, 2H), 7.0 (m, 1H), 4.4 (q, 2H), 1.4 (t, 3H).

10

A mixture of 3,5-di-fluorobenzoic acid ethyl ester (8.79 g, 47.5 mmol) and morpholine (20 ml) in dimethylsulphoxide (250 ml) was heated at 100 °C with stirring for 3 days. The reaction was cooled and then partitioned between diethyl ether and water. The aqueous layer was extracted several times with diethyl ether and the organics were combined and dried over  $\text{MgSO}_4$  before filtering the solution and evaporating the solvent under reduced pressure. The residue was subjected to purification by flash chromatography on silica gel. Eluting with 1:4 ethyl acetate: petroleum ether afforded 3-fluoro-5-morpholin-4-yl-benzoic acid ethyl ester as a yellow oil (4.8 g);  $\delta_{\text{H}}$  (400MHz,  $\text{CDCl}_3$ ) 7.4 (s, 1H), 7.2 (d, 1H), 6.8 (d, 1H), 4.4 (q, 2H), 3.8 (t, 4H), 3.2 (t, 4H), 1.4(t, 3H).

15

20

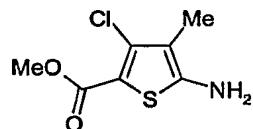
A solution of 3-fluoro-5-morpholin-4-yl-benzoic acid ethyl ester (4.8 g, 18.9 mmol) in ethanol (20 ml) was treated with 2N sodium hydroxide (20 ml) and the reaction mixture was stirred at room temperature overnight. The reaction mixture was evaporated under reduced pressure and the residue was partitioned between ethyl

25

acetate and water. The aqueous layer was acidified with 2*N* HCl and the solid precipitate was filtered, washed with diethyl ether and then dried to give the title compound as a white solid (3.1 g). LC MS - M+H 226

1B. Preparation of 3-chloro-4-methyl-5-aminothiophene-2-carboxylic acid methyl ester

5    ester



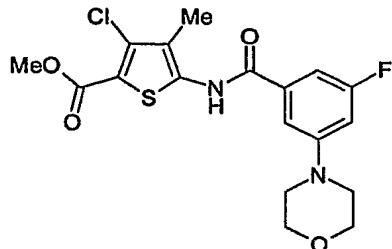
To a solution of 3-chloro-4-methyl-thiophene-2-carboxylic acid methyl ester (9 g, 47.37 mmol) in acetic anhydride (50 ml) and dichloromethane (70 ml) was added a mixture of acetic acid and concentrated nitric acid (5:1, 60 ml) at room temperature.

10   The resulting solution was then heated to 80°C for a period of 24 hours. Upon cooling, the solvent was removed under reduced pressure and the residue was dissolved in dichloromethane (250 ml). The organic solution was washed with saturated sodium bicarbonate solution (50 ml) and brine (50 ml) before drying over MgSO<sub>4</sub>. The resulting solution was filtered and the solvent was removed under reduced pressure to afford the crude product (12.9 g) which was used immediately in the next step without purification.

To a solution of the crude 3-chloro-4-methyl-5-nitrothiophene-2-carboxylic acid methyl ester (12.9 g, 54.9 mmol) in dioxane (250 ml) and water (50 ml) was added iron powder (27.6 g, 0.494 mol) followed by iron sulphate heptahydrate (33.6 g, 0.121 mol). The reaction mixture was then heated to reflux for 4 hours before cooling to room temperature. The solvent was then removed under reduced pressure and the residue was partitioned between ethyl acetate (150 ml) and 1*N* HCl (100 ml). The organic layer was separated and the aqueous layer was then basified with saturated sodium bicarbonate solution. The solution was extracted with ethyl acetate (2 x 250 ml), the organic layers were combined, dried (MgSO<sub>4</sub>), filtered and the solvent was removed under reduced pressure. The residue was subjected to purification by flash column chromatography on silica gel, eluting with 15% ethyl

acetate/petroleum ether to afford the title compound as an off white crystalline solid (1.77 g, 18% over two steps); LC MS M+H 206

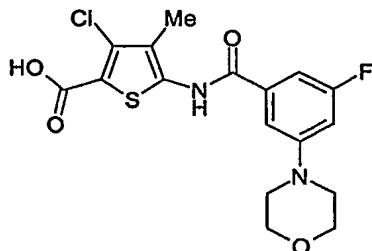
1C. 3-Chloro-5-(3-fluoro-5-morpholin-4-yl-benzoylamino)-4-methyl-thiophene-2-carboxylic acid methyl ester



5

To a solution of 3-morpholino-5-fluorobenzoic acid (2.42 g, 10.75 mmol) in dichloromethane (100 ml) was added oxalyl chloride (1.11 ml, 12.90 mmol) followed by dimethylformamide (2 drops). The resulting solution was then stirred at room temperature, under an atmosphere of nitrogen, for a period of 4 hours. The solvent was then removed under reduced pressure and the residue was azeotroped to dryness by co-evaporation with toluene (2 x 50 ml). The resulting solid was then dissolved in dichloromethane (100 ml) and to the solution was added diisopropyl-ethylamine (5.62 ml, 32.19 mmol) followed by cautious addition of the aminothiophene product of Example 1B (2.2 g, 10.73 mmol). After stirring at room temperature under nitrogen for 17 hours, the reaction mixture was diluted with dichloromethane (150 ml) and partitioned with 1N HCl (50 ml). The organic layer was separated, washed successively with saturated sodium bicarbonate solution (50 ml) and brine (50 ml), dried ( $\text{MgSO}_4$ ), filtered and concentrated. Purification by flash chromatography eluting with ethyl acetate/petroleum ether (1:4) gave the title compound as a white crystalline solid (1.60 g, 36%); LC MS M+H 413

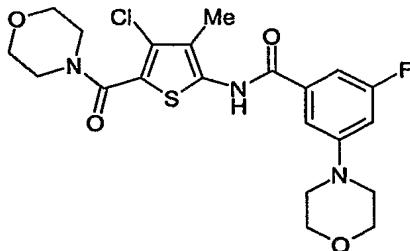
1D. 3-Chloro-5-(3-Fluoro-5-morpholin-4-yl-benzoylamino)-4-methyl-thiophene-2-carboxylic acid



To a suspension of the ester product of Example 1C (0.903 g, 1.9 mmol) in methanol:water [2:1] (30 ml) was added lithium hydroxide (0.33 g, 7.6 mmol) and the reaction mixture was heated at 60 °C overnight. The solution was evaporated

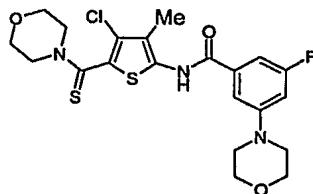
5 under reduced pressure and the residue was partitioned between ethyl acetate and water. The aqueous layer was acidified and extracted with ethyl acetate, dried ( $\text{MgSO}_4$ ), filtered and evaporated under reduced pressure to give the crude title compound as an orange foam. (0.6 g); LC MS M+H 399

1E. Preparation of N-[4-Chloro-3-methyl-5-(morpholine-4-carbonyl)-thiophen-2-yl]-3-fluoro-5-morpholin-4-yl-benzamide



To a solution of the product of Example 1D, 3-chloro-5-(3-fluoro-5-morpholin-4-yl-benzoylamino)-4-methyl-thiophene-2-carboxylic acid, (100 mg, 0.25 mmol ) in dimethylsulphoxide (2 ml) was added EDAC (72 mg, 0.37 mmol ), HOAt (50 mg, 15 0.37 mmol) followed by morpholine (22mg, 0.25mmol). The reaction mixture was stirred at room temperature overnight, and the resultant solid was filtered and washed with methanol, affording the title product as an off-white solid (40 mg). LC MS M+H 469

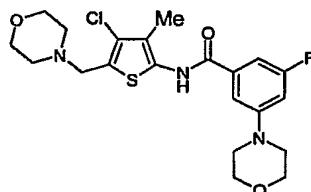
1F. Preparation of N-[4-Chloro-3-methyl-5-(morpholine-4-carbothioyl)-thiophen-2-yl]-3-fluoro-5-morpholin-4-yl-benzamide



To a solution of the product of Example 1E, N-[4-Chloro-3-methyl-5-(morpholine-4-carbonyl)-thiophen-2-yl]-3-fluoro-5-morpholin-4-yl-benzamide, (225 mg, 0.48 mmol) in dry THF (40 ml) was added Lawesson's reagent (235 mg, 0.58 mmol).

5 The reaction mixture was stirred at room temperature overnight and evaporated to dryness under reduced pressure. Purification by flash chromatography eluting with ethyl acetate/petroleum ether (1:5) gave the title compound as an orange solid (185 mg, 80%); LC MS M+H 484

**1G. Preparation of N-(4-Chloro-3-methyl-5-(morpholin-yl methyl-thiophen-2-yl)-3-fluoro-morpholin-4-yl-benzamide**



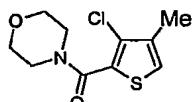
To a solution of the product of Example 1F, N-[4-Chloro-3-methyl-5-(morpholine-4-carbothioyl)-thiophen-2-yl]-3-fluoro-5-morpholin-4-yl-benzamide, (50 mg, 0.11 mmol) in dry THF (4 ml) was added methyl iodide (176 mg, 1.24 mmol). The reaction mixture was stirred at room temperature overnight and evaporated to dryness under reduced pressure. The resulting dark orange crystalline residue was re-dissolved in dry methanol (3 ml) and treated with sodium borohydride (5 mg, 0.13 mmol) and stirred at room temperature for 3 hours. The reaction mixture was diluted with 1N sodium hydroxide (8 ml) and extracted with dichloromethane. The organics were combined, washed with brine solution, dried ( $\text{MgSO}_4$ ) and evaporated to dryness under reduced pressure. Purification by preparative HPLC gave the title compound as an off-white solid (28 mg, 61 %); LC MS M+H 454

**EXAMPLE 2**

P035 (US)

Preparation of 1-[5-tert-butyl-2(4-fluoro-phenyl)-2H-pyrazol-3-yl]-3-(4-chloro-3-methyl-5-morpholin-4-ylmethyl-thiophen-2-yl) urea

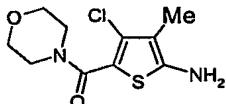
2A. Preparation of (3-chloro-4-methyl-thiophen-2-yl)-morpholin-4-yl-methanone



5

To a solution of 3-chloro-4-methyl-thiophen-2-carboxylic acid (20 g, 11.3 mmol) in dichloromethane (450 ml) was added EDAC (25.6 g, 13 mmol), HOBt (20 g, 13 mmol) followed by morpholine (10 ml, 12 mmol). The reaction mixture was stirred at room temperature overnight and then diluted with dichloromethane (500 ml). The 10 diluted reaction mixture was washed with 5 % citric acid solution (300 ml) and brine (300 ml), dried ( $\text{MgSO}_4$ ), filtered and the solvent was removed under reduced pressure to afford the title compound as a crude product (~23 g) which was used immediately in the next step without purification). LC MS M+H 246

15 2B. Preparation of (5-amino-3-chloro-4-methyl-thiophen-2-yl)-morpholin-4-yl-methanone



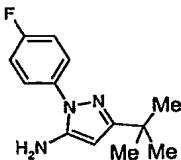
To a solution of (3-chloro-4-methyl-thiophen-2-yl)-morpholin-4-yl-methanone (Example 2B) (9.4 g, 38 mmol) in acetonitrile (600 ml) was added nitronium tetrafluoroborate (80 mmol) at 0 °C. The reaction mixture was allowed to warm to 20 room temperature over 18 hours, then diluted with water (700 ml) and extracted with dichloromethane (900 ml). The organic solution was washed with saturated sodium bicarbonate solution (500 ml) and brine (500 ml), dried ( $\text{MgSO}_4$ ), filtered and the solvent removed under reduced pressure to afford the crude product (11 g) as an orange oil, which was used immediately in the next step without purification.

25 To a solution of the crude product (11 g, 3.7 mmol) in dioxane (250 ml) and water (50 ml) was added iron powder (19 g) followed by iron sulphate heptahydrate (23 g). The reaction mixture was then heated to reflux for 4 hours before cooling to

room temperature. The solvent was then removed under reduced pressure and the residue was subjected to purification by flash column chromatography on silica gel, eluting with ethyl acetate/petroleum ether mixtures to afford the title compound as a brown oil (7.7 g); LC MS M+H 261. This was used immediately in the urea

5 formation reaction of Example 2D.

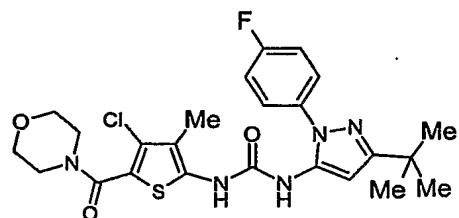
2C. Preparation of 5-tert-butyl-2-(4-fluoro-phenyl)-2H-pyrazol-3-ylamine 5



The title compound is commercially available from Butt Park of Bath, UK or can be prepared according to the following method.

10 To a stirred solution of 4-fluorophenyldiazine hydrochloride (30 g, 111.5 mmol) in EtOH (800 ml) was pivoylacetonitrile (1 equiv.) and the reaction mixture was heated at reflux for 10 hours. After cooling to room temperature, the solvent was removed under reduced pressure and the residue was subjected to purification by trituration with diethyl ether/ethyl acetate mixtures to afford the title compound as a  
15 pale brown solid (27.6 g). LC MS M+H 234

2D. Preparation of 1-[5-tert-butyl-2-(4-fluoro-phenyl)-2H-pyrazol-3-yl]-3-[4-chloro-3-methyl-5-(morpholine-4-carbonyl)-thiophen-2-yl] urea



To a stirred solution of (5-amino-3-chloro-4-methyl-thiophen-2-yl)-morpholin-4-yl-  
20 methanone (Example 2B) (8 g) in dry dichloromethane (350 ml) was added 20 % phosgene in toluene (65 ml) at room temperature and the reaction mixture was stirred for 18 hrs to allow formation of the isocyanate to go to completion. The solvent was removed under reduced pressure and the residue was re-dissolved in

dry dichloromethane (300 ml) and treated with 5-tert-butyl-2-(4-fluoro-phenyl)-2H-pyrazol-3-yl-amine (Example 2C) dropwise in dry dichloromethane (80 ml) and the reaction mixture was then stirred at room temperature for 24 hours. The reaction mixture was quenched with saturated sodium hydrogen carbonate and extracted

5 with dichloromethane (x3). The organics were combined, washed with 2N HCl, saturated brine solution, dried ( $\text{MgSO}_4$ ), filtered and the solvent removed under reduced pressure. The residue was subjected to purification by flash column chromatography on silica gel, eluting with 5 % methanol/dichloromethane to afford the title compound as a solid (10.3 g); LC MS M+H 520.

10 2E. Preparation of 1-[5-tert-butyl-2-(4-fluoro-phenyl)-2H-pyrazol-3-yl]-3-[4-chloro-3-methyl-5-(morpholine-4-carbothioyl)-thiophen-2-yl] urea

To a stirred solution of 1-[5-tert-butyl-2-(4-fluoro-phenyl)-2H-pyrazol-3-yl]-3-[4-chloro-3-methyl-5-(morpholine-4-carbothioyl)-thiophen-2-yl] urea (Example 2D) (2 g, 3.85 mmol) in dry THF was added Lawesson's reagent (1.87 g, 4.6 mmol) and the reaction mixture was stirred at room temperature overnight. The solvent was removed under reduced pressure and the residue was subjected to purification by flash column chromatography on silica gel, eluting with 1:1 ethyl acetate/hexanes to afford the title compound as a solid (1.58 g); LC MS M+H 536.

15 2F. Preparation of 1-[5-tert-butyl-2-(4-fluoro-phenyl)-2H-pyrazol-3-yl]-3-(4-chloro-3-methyl-5-morpholin-4-ylmethyl-thiophen-2-yl) urea

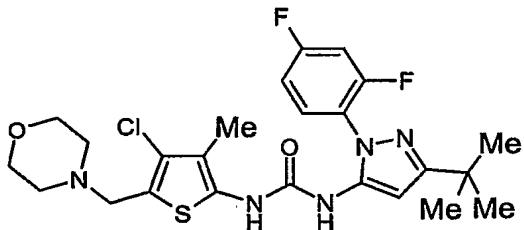
P035 (US)

To a stirred solution of (1.58g, 2.95 mmol) in dry THF (150ml) was added methyl iodide (1.9 ml, 15 equiv.) and the reaction mixture was stirred at 50 °C overnight. The solvent was removed under reduced pressure and the residue was re-dissolved in dry methanol (100 ml) and treated with sodium borohydride (140 mg, 1.05 equiv.). The reaction mixture was then stirred at room temperature for 3 hours before diluting with 1N NaOH (100 ml) and extracting with ethyl acetate (x3). The organic solutions were combined and then washed with brine, dried ( $\text{MgSO}_4$ ), filtered and the solvent was removed under reduced pressure to afford the crude product as a dark orange solid. Purification by flash column chromatography on silica gel, eluting with 3:1 ethyl acetate/hexanes, gave the title compound as an off-white solid (0.76 g); LC MS M+H 506.

### EXAMPLE 3

1-[5-tert-Butyl-2-(2,4-difluoro-phenyl)-2H-pyrazol-3-yl]-3-(4-chloro-3-methyl-5-morpholin-4-ylmethyl-thiophen-2-yl)-urea

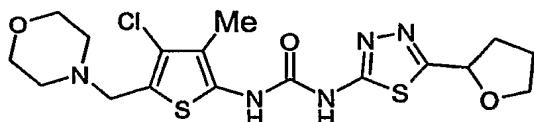
15



The title compound was prepared from (5-amino-3-chloro-4-methyl-thiophen-2-yl)-morpholin-4-yl-methanone (Example 2B) and 5-tert-butyl-2-(2,4-difluorophenyl)-2H-pyrazol-3-ylamine following the procedures described in Example 2. LC MS M+H 524

20 EXAMPLE 4

1-(4-Chloro-3-methyl-5-morpholin-4-ylmethyl-thiophen-2-yl)-3-[5-(tetrahydro-furan-2-yl)-[1,3,4]thiadiazol-2-yl]-urea



The title compound was prepared from (5-amino-3-chloro-4-methyl-thiophen-2-yl)-morpholin-4-yl-methanone (Example 2B) and 5-(tetrahydro-furan-2-yl)-[1,3,4]thiadiazole-2-ylamine (commercially available) following the procedures  
5 described in Example 2. LC MS M+H 444

### BIOLOGICAL ACTIVITY

#### EXAMPLE 5

##### p38 MAP Kinase Inhibitory Activity

###### Measurement of p38 MAP Kinase Inhibitory Activity (IC<sub>50</sub>)

10 Compounds of the invention were tested for p38 MAP kinase inhibitory activity using the protocol set out below.

In the assay, an inactive  $\alpha$  isoform of p38 mitogen-activated protein kinase was used. The structure of this kinase at 2.1-A resolution is described in the article by Wang Z, Harkins PC, Ulevitch RJ, Han J, Cobb MH and Goldsmith EJ. in Proc. Natl. Acad. Sci. U S A 1997 Mar 18;94(6):2327. The  $\alpha$  isoform of p38 MAP kinase was activated using the MKK6 kinase obtained from Upstate Biotechnology. The selective activation of p38 mitogen-activated protein (MAP) kinase isoforms by the MAP kinase kinase MKK6 is described in the article by Enslen, H; Raingeaud, J and Davis, R J in The Journal of Biological Chemistry, Volume 273, 20 Issue 3, January 16, 1998, Pages 1741-1748.

The protocol was as follows:  
The protocol was as follows:  
1 ml of fresh assay buffer (25 mM HEPES pH 7.4, 25 mM  $\beta$ -glycerophosphate, 5 mM EDTA, 15 mM MgCl<sub>2</sub>, 100  $\mu$ M ATP, 1 mM sodium orthovanadate, 1 mM DTT), 35  $\mu$ g of inactive purified  $\alpha$  p38 and 0.12  $\mu$ g of active MKK6 (1688 U/mg – 25 Upstate Biotechnology) are mixed and incubated at room temperature overnight to activate the p38. The activated p38 is then diluted sixfold with assay buffer without ATP, and 10  $\mu$ l mixed with 5  $\mu$ l of various dilutions of the test compound in DMSO

(up to 1.7%) in a 96 well plate and incubated at room temperature for 1.5 hours.

Next, 10 µl of MBP mix (150 µl 10 x strength assay buffer (250 mM HEPES pH 7.4, 250 mM β-glycerophosphate, 50 mM EDTA, 150 mM MgCl<sub>2</sub>), 1.5 µl of 10 mM DTT & 10 mM sodium orthovanadate, 17.5 µl of 10mM ATP, 713 µl H<sub>2</sub>O, 35

5 µCi γ<sup>33</sup>P-ATP, 100 µl of myelin basic protein (MBP) (5 mg/ml)) is added to each well. MBP is a protein of bovine origin having a molecular weight of 18.4kDa and is obtained from Upstate Biotechnology. The reaction is allowed to proceed for 50 minutes before being stopped with an excess of ortho-phosphoric acid (5 µl at 12.5%).

10 γ<sup>33</sup>P-ATP which remains unincorporated into the myelin basic protein is separated from phosphorylated MBP on a Millipore MAPH filter plate. The wells of the MAPH plate are wetted with 0.5% orthophosphoric acid, and then the results of the reaction are filtered with a Millipore vacuum filtration unit through the wells. Following filtration, the residue is washed twice with 200 µl of 0.5%

15 orthophosphoric acid. Once the filters have dried, 25 µl of Microscint 20™ scintillant is added, and then counted on a Packard Topcount for 30 seconds. The % inhibition of the p38 activity is calculated and plotted in order to determine the concentration of test compound required to inhibit 50% of the p38 activity (IC<sub>50</sub>).

The compounds of Examples 1 to 4 were tested using the assay and all were found

20 to inhibit p38 activity. All of the compounds had IC<sub>50</sub> values of less than 5µM.

#### EXAMPLE 6

##### Inhibition of LPS-Induced TNF-α Production in THP-1 Cells. *In Vitro* Assay

The ability of the compounds of this invention to inhibit the TNF-α release may be determined using a minor modification of the methods described in Rawlins P., et al., "Inhibition of endotoxin-induced TNF-α production in macrophages by 5Z-7-oxo-zeaenol and other fungal resorcylic acid lactones," *International J. of Immunopharmacology*, 21, 799, (1999).

THP-1 cells, human monocytic leukaemic cell line, ECACC) are maintained in culture medium [RPMI 1640 (Invitrogen) and 2mM L-Glutamine supplemented

with 10% foetal bovine serum (Invitrogen)] at approximately 37°C in humidified 5% CO<sub>2</sub> in stationary culture.

THP-1 cells are suspended in culture medium containing 50ng/ml PMA (SIGMA), seeded into a 96-well tissue culture plate (IWAKI) at  $1 \times 10^5$  cells/well (100µl/well)

5 and incubated as described above for approximately 48h. The medium is then aspirated, the wells washed twice in Phosphate Buffered Saline and 1µg/ml LPS (SIGMA) in culture medium is added (200µl/well).

Test compounds are reconstituted in DMSO (SIGMA) and then diluted with the culture medium such that the final DMSO concentration is 0.1%. Twenty microlitre

10 aliquots of test solution or medium only with DMSO (solvent control) are added to triplicate wells immediately following LPS addition, and incubated for 6h as described above. Culture supernatants are collected and the amount of human TNF-α present is determined by ELISA (R&D Systems) performed according to the manufacturer's instructions.

15 The IC<sub>50</sub> is defined as the concentration of the test compound corresponding to half maximal inhibition of the control activity by non-linear regression analysis of their inhibition curves.

#### PHARMACEUTICAL FORMULATIONS

EXAMPLE 7

20 (i) Tablet Formulation  
A tablet composition containing a compound of the formula (I) is prepared by mixing 50mg of the compound with 197mg of lactose (BP) as diluent, and 3mg magnesium stearate as a lubricant and compressing to form a tablet in known manner.

25 (ii) Capsule Formulation  
A capsule formulation is prepared by mixing 100mg of a compound of the formula (I) with 100mg lactose and filling the resulting mixture into standard opaque hard gelatin capsules.

**(iii) Aerosol Formulation**

An aerosol formulation for administration by inhalation is prepared by weighing micronised compound of the formula (I) (60 mg) directly into an aluminium can

5 and then adding 1,1,1,2-tetrafluorethane (to 13.2 g) from a vacuum flask. A metering valve is crimped into place and the sealed can is sonicated for five minutes. The resulting formulation delivers the compound of formula (I) as an aerosol in an amount of 250 mg of per actuation.

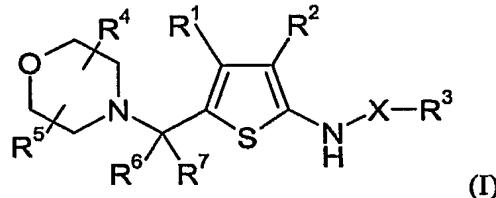
**Equivalents**

10 The foregoing examples are presented for the purpose of illustrating the invention and should not be construed as imposing any limitation on the scope of the invention. It will readily be apparent that numerous modifications and alterations may be made to the specific embodiments of the invention described above and illustrated in the examples without departing from the principles underlying the

15 invention. All such modifications and alterations are intended to be embraced by this application.

CLAIMS

1. A compound of the formula (I):



wherein:

5        R<sup>1</sup> and R<sup>2</sup> are the same or different and each is selected from hydrogen, saturated C<sub>1-3</sub> hydrocarbyl, halogen and cyano;

10      X is selected from C=O, C=S, C(=O)NH, C(=S)NH, C(=O)O, C(=O)S, C(=S)O and C(=S)S;

15      R<sup>3</sup> is selected from aryl and heteroaryl groups each having from 5 to 12 ring members and being unsubstituted or substituted by one or more substituent groups R<sup>10</sup> selected from halogen, hydroxy, trifluoromethyl, cyano, nitro, carboxy, amino, mono- or di-C<sub>1-4</sub> hydrocarbylamino, carbocyclic and heterocyclic groups having from 3 to 12 ring members; a group R<sup>a</sup>-R<sup>b</sup> wherein R<sup>a</sup> is a bond, O, CO, X<sup>1</sup>C(X<sup>2</sup>), C(X<sup>2</sup>)X<sup>1</sup>, X<sup>1</sup>C(X<sup>2</sup>)X<sup>1</sup>, S, SO, SO<sub>2</sub>, NR<sup>c</sup>, SO<sub>2</sub>NR<sup>c</sup> or NR<sup>c</sup>SO<sub>2</sub>; and R<sup>b</sup> is selected from hydrogen, carbocyclic and heterocyclic groups having from 3 to 12 ring members, and a C<sub>1-8</sub> hydrocarbyl group optionally substituted by one or more substituents selected from hydroxy, oxo, halogen, cyano, nitro, carboxy, amino, mono- or di-C<sub>1-4</sub> hydrocarbylamino, carbocyclic and heterocyclic groups having from 3 to 12 ring members and wherein one or more carbon atoms of the C<sub>1-8</sub> hydrocarbyl group may optionally be replaced by O, S, SO, SO<sub>2</sub>, NR<sup>c</sup>, X<sup>1</sup>C(X<sup>2</sup>), C(X<sup>2</sup>)X<sup>1</sup> or X<sup>1</sup>C(X<sup>2</sup>)X<sup>1</sup>; or two adjacent groups R<sup>10</sup>, together with the carbon atoms or heteroatoms to which they are attached may form a 5-membered heteroaryl ring or a 5- or 6-membered non-aromatic heterocyclic ring, wherein the said heteroaryl and heterocyclic groups contain up to 3 heteroatom ring members selected from N, O and S;

20      R<sup>c</sup> is selected from hydrogen and C<sub>1-4</sub> hydrocarbyl; and

$X^1$  is O, S or NR<sup>c</sup> and  $X^2$  is =O, =S or =NR<sup>c</sup>;

R<sup>4</sup> and R<sup>5</sup> are the same or different and are selected from hydrogen and methyl; or one of R<sup>4</sup> and R<sup>5</sup> is selected from hydroxymethyl and ethyl and the other is hydrogen; and

5           R<sup>6</sup> and R<sup>7</sup> are the same or different and are selected from hydrogen and methyl.

2.          A compound according to claim 1 wherein R<sup>3</sup> is a monocyclic aryl or heteroaryl group.

3.          A compound according to claim 1 wherein R<sup>3</sup> is selected from unsubstituted or substituted phenyl, indenyl, tetrahydronaphthyl, naphthyl, pyridyl, 10        pyrrolyl, furanyl, thienyl, imidazolyl, oxazolyl, oxadiazolyl, oxatriazolyl, isoxazolyl, thiazolyl, isothiazolyl, thiadiazolyl (e.g. [1,3,4]-thiadiazolyl), pyrazolyl, pyrazinyl, pyrimidinyl, triazinyl, quinolinyl, isoquinolinyl, tetrazolyl, benzfuranyl, chromanyl, thiochromanyl, benzimidazolyl, 15        benzoxazolyl, benzisoxazolyl, benzthiazolyl and benzisothiazolyl, isobenzofuranyl, isoindolyl, indolizinyl, indolinyl, isoindolinyl, purinyl (e.g., adenine, guanine), indazolyl, benzodioxolyl, chromenyl, isochromenyl, chroman, isochromanyl, benzodioxanyl, quinolizinyl, benzoxazinyl, benzodiazinyl, pyridopyridinyl, pyrazolopyridine, 20        pyrazolopyrimidine, pyrrolopyridine, pyrrolopyrimidine, quinoxalinyl, quinazolinyl, cinnolinyl, phthalazinyl, naphthyridinyl and pteridinyl.

4.          A compound according to claim 2 wherein R<sup>3</sup> is a monocyclic aryl group.

5.          A compound according to claim 2 wherein R<sup>3</sup> is a monocyclic heteroaryl group containing at least one nitrogen atom.

25        6.          A compound according to claim 5 wherein the heteroaryl group is selected from pyrazolyl and thiadiazolyl (e.g. [1,3,4]-thiadiazolyl).

7.          A compound according to any one of the preceding claims wherein the aryl group or heteroaryl group R<sup>3</sup> contains one or more substituent groups R<sup>10</sup>

selected from halogen, carbocyclic and heterocyclic groups having from 4 to 7 ring members and optionally substituted C<sub>1-8</sub> hydrocarbyl groups.

8. A compound according to claim 7 wherein the group R<sup>3</sup> contains a substituent R<sup>10</sup> which is a carbocyclic or heterocyclic group having from 4 to 7 ring members.  
5
9. A compound according to claim 8 wherein the carbocyclic or heterocyclic group is linked to the aryl or heteroaryl ring via a carbon nitrogen bond.
10. A compound according to claim 9 wherein the carbocyclic or heterocyclic group is a 4 to 7 membered (more typically 5 to 6 membered) heterocyclic group R<sup>8</sup> containing at least one nitrogen atom or oxygen atom ring member.  
10
11. A compound according to claim 10 wherein R<sup>8</sup> is selected from morpholino, piperidino, piperazino, N-methyl piperazine, tetrahydrofuranyl and pyrrolidino.
- 15 12. A compound according to claim 11 wherein R<sup>8</sup> is morpholino.
13. A compound according to claim 11 wherein R<sup>8</sup> is tetrahydrofuranyl (e.g. 2-tetrahydrofuranyl).
14. A compound according to any one of the preceding claims wherein R<sup>3</sup> is a phenyl group bearing one or two *meta* substituents.
- 20 15. A compound according to claim 14 wherein one *meta* position on the phenyl ring is unsubstituted or is substituted by a group R<sup>10</sup> selected from fluorine, chlorine, methoxy, trifluoromethoxy, trifluoromethyl, ethyl, methyl and isopropyl; and the other *meta* position is substituted by a group selected from fluorine, chlorine, methoxy, trifluoromethoxy, trifluoromethyl, ethyl, methyl, isopropyl, isobutyl, t-butyl, phenyl, substituted phenyl, and five and six membered monocyclic heterocyclic groups.  
25

16. A compound according to claim 15 wherein both *meta* positions on the phenyl ring are substituted, one substituent being a halogen, preferably fluoro, and the other substituent being a group R<sup>8</sup> as defined in any one of claims 10 to 13.
- 5 17. A compound according to claim 16 wherein one substituent is fluorine and the other substituent is morpholine-4-yl.
18. A compound according to claim 8 wherein R<sup>3</sup> is a pyrazole group substituted by up to two substituent groups, for example 1 or 2 substituent groups.
- 10 19. A compound according to claim 18 wherein the pyrazole group is substituted by two substituent groups that are located on non-adjacent ring members.
20. A compound according to claim 18 or claim 19 wherein at least one of the substituents is located at a position *meta* or β with respect to the ring member linked to the group X.
- 15 21. A compound according to any one of claims 18 to 20 wherein the pyrazole group ring is substituted by an optionally substituted phenyl group (e.g. 4-fluorophenyl or 2,4-difluorophenyl) and a C<sub>1-4</sub> hydrocarbyl group (e.g. *tert*-butyl).
- 20 22. A compound according to any one of the preceding claims wherein X is C=O or C(=O)NH.
23. A compound according to claim 22 wherein X is C=O.
24. A compound according to claim 22 wherein X is C(=O)NH.
- 25 25. A compound according to any one of the preceding claims wherein R<sup>1</sup> is selected from hydrogen, saturated C<sub>1-3</sub> hydrocarbyl and halogen (e.g. chlorine and fluorine).

26. A compound according to any one of the preceding claims wherein R<sup>2</sup> is selected from hydrogen, saturated C<sub>1-3</sub> hydrocarbyl and halogen (e.g. chlorine and fluorine).
27. A compound according to any one of the preceding claims wherein R<sup>1</sup> is a halogen.  
5
28. A compound according to claim 27 wherein the halogen is chlorine.
29. A compound according to any one of the preceding claims wherein R<sup>2</sup> is a saturated C<sub>1-3</sub> hydrocarbyl group.
30. A compound according to claim 29 wherein the saturated C<sub>1-3</sub> hydrocarbyl group is methyl.  
10
31. A compound according to any one of the preceding claims wherein the total number of carbon, halogen and nitrogen atoms making up the substituent groups R<sup>1</sup> and R<sup>2</sup> does not exceed 5.
32. A compound according to claim 31 wherein the total number of carbon, halogen and nitrogen atoms making up the substituent groups R<sup>1</sup> and R<sup>2</sup> is in the range 0 to 4, for example 0, 1, 2, or 3.  
15
33. A compound according to any one of the preceding claims containing a combination of groups R<sup>1</sup> and R<sup>2</sup> selected from: (a) R<sup>1</sup> = chlorine & R<sup>2</sup> = methyl; (b) R<sup>1</sup> = chlorine & R<sup>2</sup> = hydrogen; (c) R<sup>1</sup> = hydrogen & R<sup>2</sup> = hydrogen; (d) R<sup>1</sup> = methyl & R<sup>2</sup> = hydrogen; (e) R<sup>1</sup> = cyano & R<sup>2</sup> = methyl; and (f) R<sup>1</sup> = methyl & R<sup>2</sup> = cyano.  
20
34. A compound according to claim 3 wherein the combination of groups R<sup>1</sup> and R<sup>2</sup> is combination (a).
35. A compound according to any one of the preceding claims wherein R<sup>4</sup> is hydrogen.  
25

36. A compound according to any one of the preceding claims wherein R<sup>5</sup> is hydrogen.
37. A compound according to any one of the preceding claims wherein R<sup>6</sup> is hydrogen.
- 5 38. A compound according to any one of the preceding claims wherein R<sup>7</sup> is hydrogen.
39. A compound according to any one of the preceding claims wherein when X is C=O or C=S and R<sup>3</sup> bears a substituent group R<sup>a</sup>-R<sup>b</sup> attached to an atom adjacent the atom in R<sup>3</sup> to which X is attached, and R<sup>b</sup> is a carbocyclic or heterocyclic group or C<sub>1-8</sub> hydrocarbyl substituted by a carbocyclic or heterocyclic group, then R<sup>a</sup> is selected from a bond, O, CO, X<sup>1</sup>C(X<sup>2</sup>)X<sup>1</sup>, S, SO and SO<sub>2</sub>.
- 10 40. A compound according to any one of the preceding claims wherein, when X is CO, R<sup>3</sup> is other than a fused bicyclic aromatic or partially aromatic group bearing a substituent on a ring atom adjacent the ring atom to which X is attached.
- 15 41. A compound selected from:  
N-(4-chloro-3-methyl-5-(morpholin-yl methyl-thiophen-2-yl)-3-fluoro-morpholin-4-yl-benzamide;
- 20 1-[5-tert-butyl-2(4-fluoro-phenyl)-2H-pyrazol-3-yl]-3-(4-chloro-3-methyl-5-morpholin-4-ylmethyl-thiophen-2-yl) urea;  
1-[5-tert-butyl-2-(2,4-difluoro-phenyl)-2H-pyrazol-3-yl]-3-(4-chloro-3-methyl-5-morpholin-4-ylmethyl-thiophen-2-yl)-urea; and  
1-(4-chloro-3-methyl-5-morpholin-4-ylmethyl-thiophen-2-yl)-3-[5-(tetrahydro-furan-2-yl)-[1,3,4]thiadiazol-2-yl]-urea.
- 25 42. A compound according to any one of the preceding claims in the form of a salt, solvate or N-oxide.

43. A compound of the formula (I) as defined in any one of claims 1 to 42 for use in the prophylaxis or treatment of a disease state or condition mediated by a p38 MAP kinase.

44. The use of a compound of the formula (I) as defined in any one of claims 1 to 42 for the manufacture of a medicament for the prophylaxis or treatment of a disease state or condition mediated by a p38 MAP kinase.

45. A method for the prophylaxis or treatment of a disease state or condition mediated by a p38 MAP kinase, which method comprises administering to a subject (e.g. a human subject) in need thereof a compound of the formula (I) as defined in any one of claims 1 to 42.

46. A method of inhibiting a p38 MAP kinase, which method comprises contacting the p38 MAP kinase with a kinase-inhibiting compound of the formula (I) as defined in any one of claims 1 to 42.

47. A method of modulating a cellular process by inhibiting the activity of a p38 MAP kinase using a compound of the formula (I) as defined in any one of claims 1 to 42, which method comprises bringing the compound of formula (I) into contact with a cellular environment containing the p38 MAP kinase.

48. A compound of the formula (I) as defined in any one of claims 1 to 42 for use in medicine, for example for use in therapy.

49. A pharmaceutical composition comprising a compound of the formula (I) as defined in any one of claims 1 to 42 together with a pharmaceutically acceptable carrier.

50. A compound for use, use or method as defined in any one of claims 43 to 49 wherein the disease state or condition mediated by a p38 MAP kinase is selected from:

(i) inflammatory and arthritic diseases and conditions such as Reiter's syndrome, acute,synovitis, rheumatoid arthritis, osteoarthritis, rheumatoid

spondylitis, gouty arthritis, traumatic arthritis, rubella arthritis, psoriatic arthritis, graft vs. host reaction and allograft rejections;

(ii) chronic inflammatory lung diseases such as emphysema, chronic pulmonary inflammatory disease, chronic obstructive pulmonary disease (COPD), adult respiratory distress syndrome and acute respiratory distress syndrome (ARDS);

(iii) lung diseases and conditions such as tuberculosis, silicosis, pulmonary sarcoidosis, pulmonary fibrosis and bacterial pneumonia;

(iv) inflammatory diseases and conditions of the enteric tract such as inflammatory bowel disease, Crohn's disease and ulcerative colitis;

(v) toxic shock syndrome and related diseases and conditions such as sepsis, septic shock, endotoxic shock, gram negative sepsis and the inflammatory reaction induced by endotoxin;

(vi) Alzheimer's disease;

(vii) reperfusion injury;

(viii) diseases and conditions selected from atherosclerosis; muscle degeneration; gout; cerebral malaria; bone resorption diseases; fever and myalgias due to infection, such as influenza; cachexia, in particular cachexia secondary to infection or malignancy, cachexia secondary to acquired immune deficiency syndrome (AIDS); AIDS; ARC (AIDS related complex); keloid formation; scar tissue formation; pyresis and asthma.

51. A compound for use, use or method as defined in claim 50 wherein the disease state or condition is selected from inflammatory diseases and conditions, rheumatoid arthritis and osteoarthritis.

25 52. A compound for use, use or method as defined in claim 50 wherein the disease state or condition is chronic obstructive pulmonary disease (COPD).

53. A compound of the formula (I) as defined in any one of claims 1 to 42 for use in the prophylaxis or treatment of a disease state or condition selected from the disease states and conditions set out in claims 50 to 52.

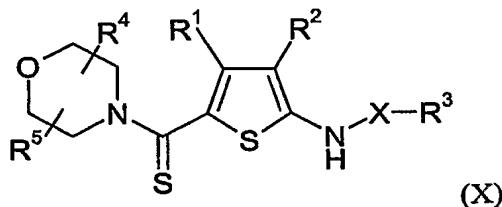
54. The use of a compound of the formula (I) as defined in any one of claims 1 to 42 for the manufacture of a medicament for the prophylaxis or treatment of a disease state or condition selected from the disease states and conditions set out in claims 50 to 52.

55. A method for the prophylaxis or treatment of a disease state or condition selected from the disease states and conditions set out in claims 50 to 52, which method comprises administering to a subject (e.g. a human subject) in need thereof a compound of the formula (I) as defined in any one of claims 1 to 42.

56. A pharmaceutical composition for administration by inhalation, the composition comprising a compound as defined in any one of claims 1 to 42 together with a pharmaceutically acceptable carrier.

57. A pharmaceutical composition according to claim 56 which is selected from inhalable dry powder compositions and aerosol compositions.

58. A process for the preparation of a compound as defined in any one of claims 1 to 42, which process comprises the S-alkylation (e.g. methylation) of a compound of the formula (X):



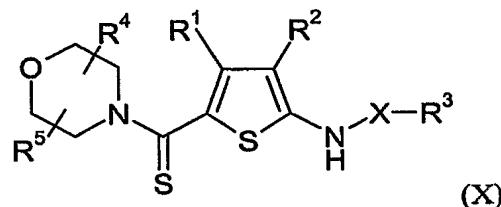
using an alkylating agent such as methyl iodide to give a thioimide intermediate followed by:

(i) reduction of the thioimide intermediate to give a compound of formula (I) in which R<sup>6</sup> and R<sup>7</sup> are hydrogen by means of a reducing agent such as a borohydride; or

5 (ii) treating the thioimide intermediate with methyl lithium or a methyl Grignard reagent, followed by a reducing agent such as a borohydride to give a compound of the formula (I) in which one of R<sup>6</sup> and R<sup>7</sup> is methyl; or

10 (iii) treating the thioimide intermediate with more than one equivalent of methyl lithium or a methyl Grignard reagent to give a compound of the formula (I) in which both R<sup>6</sup> and R<sup>7</sup> are methyl.

59. A compound of the formula (X):



wherein R<sup>1</sup> to R<sup>5</sup> and X are as defined in any one of claims 1 to 42.

## APPLICATION DATA SHEET

Electronic Version v14  
Stylesheet Version v14.0

|                                 |   |         |
|---------------------------------|---|---------|
| Title of Invention              | PHARMACEUTICAL COMPOUNDS                |         |
| Application Type:               | provisional, utility                    |         |
| Attorney Docket Number:         | 2245.009P                               |         |
| Correspondence address:         |   |         |
| Customer Number:                | 23405                                   | *23405* |
| Inventors Information:          |   |         |
| <u>Inventor 1:</u>              |   |         |
| Applicant Authority Type:       | Inventor                                |         |
| Citizenship:                    | GB                                      |         |
| Given Name:                     | Adrian                                  |         |
| Middle Name:                    | Liam                                    |         |
| Family Name:                    | Gill                                    |         |
| City of Residence:              | Cambridge                               |         |
| Country of Residence:           | GB                                      |         |
| Address-1 of Mailing Address:   | c/o Astex Technology Ltd.               |         |
| Address-2 of Mailing Address:   | 436 Cambridge Science Park, Milton Road |         |
| City of Mailing Address:        | Cambridge                               |         |
| State of Mailing Address:       |   |         |
| Postal Code of Mailing Address: | CB4 0QA                                 |         |
| Country of Mailing Address:     | GB                                      |         |
| Phone:                          |   |         |
| Fax:                            |   |         |
| E-mail:                         |   |         |
| <u>Inventor 2:</u>              |   |         |
| Applicant Authority Type:       | Inventor                                |         |
| Citizenship:                    | GB                                      |         |
| Given Name:                     | Maria                                   |         |
| Family Name:                    | Carr                                    |         |
| City of Residence:              | Cambridge                               |         |
| Country of Residence:           | GB                                      |         |
| Address-1 of Mailing Address:   | c/o Astex Technology Ltd.               |         |

Address-2 of Mailing Address: 436 Cambridge Science Park, Milton Road

City of Mailing Address: Cambridge

State of Mailing Address:

Postal Code of Mailing Address: CB4 0QA

Country of Mailing Address: GB

Phone:

Fax:

E-mail: